SEPTEMBER 1957

# Journal

VOL. 49 • NO. 9

## AMERICAN WATER WORKS ASSOCIATION

*Smooth sailing on Indiana's third largest lake—Indianapolis Water Company's 1,800-acre Geist Reservoir*

*In this issue:*

# Journal

AMERICAN WATER WORKS ASSOCIATION

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September 1957

Vol. 49 • No. 9

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Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 2 Park Ave., New York 16, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918. $7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—60 cents; single copies to nonmembers—85 cents. Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*. Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

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**Sep. 24–25**—Rocky Mountain Section, at La Fonda Hotel, Santa Fe, N.M. Secretary, J. W. Davis, 301 Continental Oil Bldg., Denver 2, Colo.

**Sep. 25–27**—Michigan Section, at Leland Hotel, Detroit. Secretary, T. L. Vander Velde, Chief, Sec. of Water Supply, State Dept. of Health, Lansing 4.

**Sep. 25–27**—North Central Section, at Gardner Hotel, Fargo, N.D. Secretary, L. N. Thompson, 216 Court House Bldg., St. Paul 2, Minn.

**Sep. 29–Oct. 1**—Missouri Section, at Sheraton-Jefferson Hotel, St. Louis. Secretary, W. A. Kramer, State Office Bldg., Jefferson City.

**Oct. 13–16**—Southwest Section, at Skirvin Hotel, Oklahoma City, Okla. Secretary, Leslie A. Jackson, Mgr.-Engr., Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

**Oct. 16–18**—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

(*Continued on page 8*)

## Coming Meetings

(Continued from page 6)

**Oct. 17–18**—Canadian Section, Maritime Branch, at Nova Scotian Hotel, Halifax, N.S. Secretary, J. D. Kline, Asst. Mgr. & Chief Engr., Public Service Com., 162 Lady Hammond Rd., Halifax, N.S.

**Oct. 20–23**—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Public Service Com., 119 W. Commercial St., Yazoo City, Miss.

**Oct. 23–24**—West Virginia Section, at McClure Hotel, Wheeling. Secretary, H. W. Hetzer, Engr., West Virginia Water Service Co., Box 1906, Charleston 27.

**Oct. 24–26**—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Manager, R. D. Wood Co., 683 Prospect St., Maplewood.

**Oct. 29–Nov. 1**—California Section, at Hotel St. Claire, San Jose. Secretary, Henry J. Ongerth, Sr. San. Engr., Bureau of San. Eng., 2151 Berkeley Way, Berkeley.

**Oct. 30–Nov. 1**—Chesapeake Section, at Sheraton-Park Hotel, Washington, D.C. Secretary, C. J. Lauter, 6955—33rd St., N.W., Washington, D.C.

**Nov. 6–8**—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

**Nov. 10–13**—Florida Section, at Roosevelt Hotel, Jacksonville. Secretary, J. D. Roth, P.O. Bin "O," Miami Beach 39.

**Nov. 11–13**—North Carolina Section, at Hotel Sir Walter, Raleigh. Secretary, W. E. Long Jr., State Stream Sanitation Com., Raleigh.

## OTHER ORGANIZATIONS

Oct. 6–9—Annual Conference & Products Exhibit, National Institute of Governmental Purchasing, at Netherland Hilton Hotel, Cincinnati, Ohio. Write: Albert H. Hall, Exec. Vice-Pres., 1001 Connecticut Ave., N.W., Washington 6, D.C.

Oct. 7–10—Federation of Sewage & Industrial Wastes Assns., at Statler Hotel, Boston, Mass.

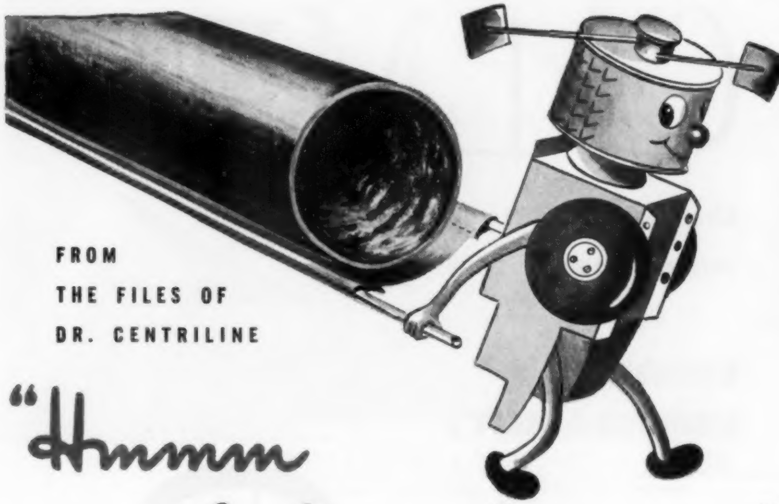
Oct. 24–25—Engineers General Assembly, joint conference of Engineers Joint Council and Engineers Council for Professional Development, at Statler Hotel, New York, N.Y.

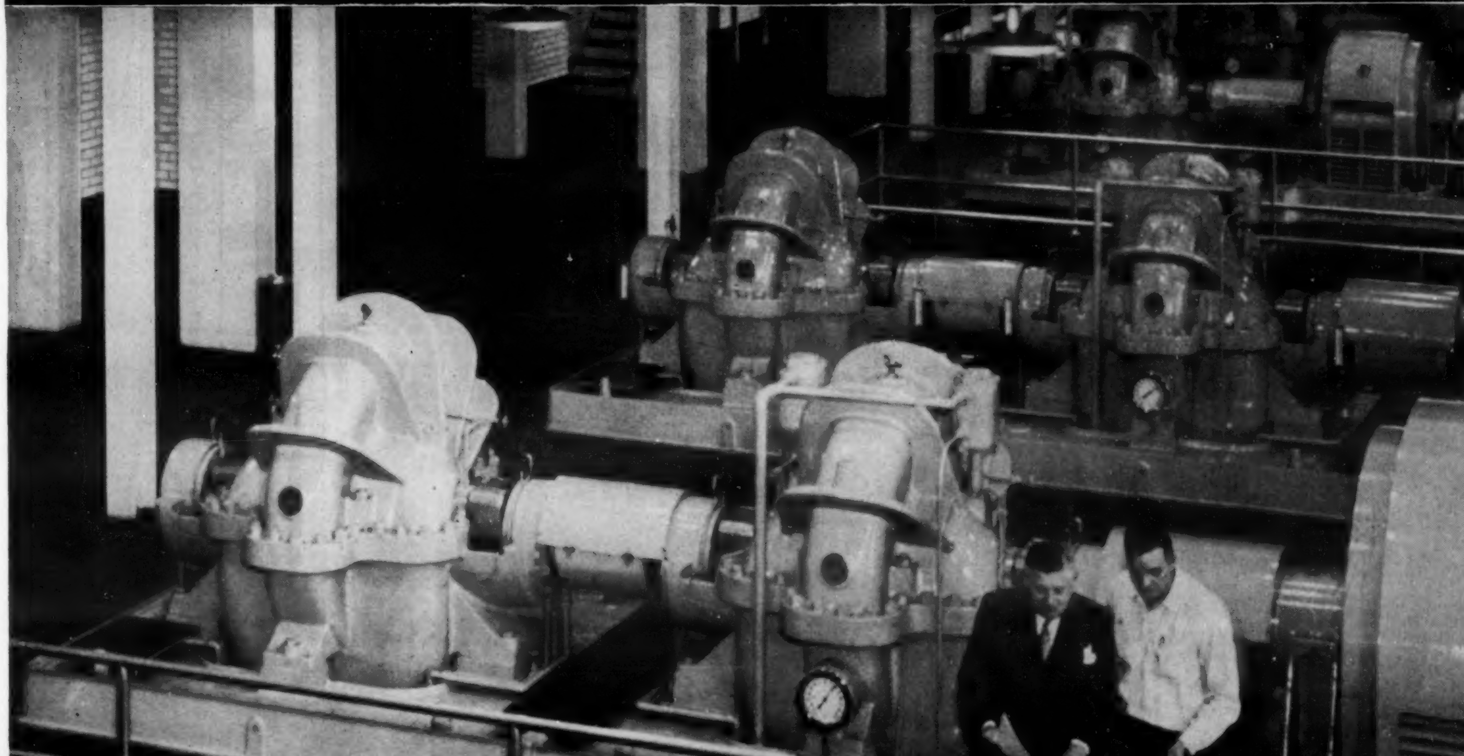
Nov. 2–8—World Metallurgical Congress, sponsored by American Society for Metals, at Chicago, Ill.

Nov. 11–15—Annual Meeting, American Public Health Assn., Cleveland, Ohio.

Nov. 13–15—National Conference on Standards, American Standards Assn., at St. Francis Hotel, San Francisco, Calif.

Dec. 2–6—Exposition of Chemical Industries, at the Coliseum, New York, N.Y.





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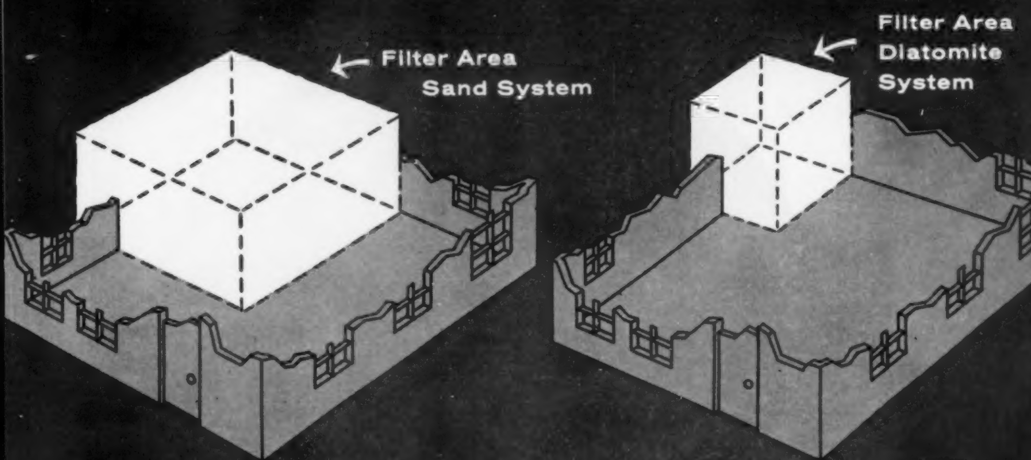


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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 49 • SEPTEMBER 1957 • NO. 9

# Present Bond Market Status

George I. McKelvey Jr.

*An address presented on May 16, 1957, at the Annual Conferense, Atlantic City, N.J., by George I. McKelvey Jr., Assoc., Tucker, Anthony & R. L. Day, New York, N.Y.*

TAKING a quick look ahead, I foresee that the water works industry is faced with borrowing close to \$500,000,000 annually (most of it by municipally owned plants) for quite a few years, in order to take care of the needs of our rapidly growing population as well as the increased use of water per capita. Naturally, you are concerned with the interest you will have to pay for those borrowed funds. It is that very demand on your part for money, plus the demand for new streets, roads, schools, and firehouses, combined with the demand of commercial and industrial organizations for their expansion plans, that is making money expensive to borrow. In the municipal bond field, for the first 4 months of 1957, new flotations reached the staggering total of 2.46 billion dollars, which is an all-time high.

I wish I could promise you that interest rates would reverse their upward trend—a trend which started back in 1950—but I am afraid I cannot see a reverse of any great extent. We might gain perspective by reviewing the past, for actually the interest rate is not really high. Surely, there are some who remember when savings banks paid 4–4½ per cent on deposits. That meant they had to buy 5–5½ per cent bonds to do so. Many recall when nothing less than 6 per cent was ever discussed for a home mortgage—the only dispute being how much premium one had to pay to get the mortgage, which of course raised the actual rate above the 6 per cent mark.

## Credit Background

Prior to 1935, interest rates were always higher than they are today. This I can best illustrate by using an index of the average rate paid by a cross section of large American cities. This index goes back as far as 1890. From that date until about 1910, rates fluctuated between a low of 3¼ per cent and a high of 4¼ per cent. (So that you can get your bearings, the

average today is 3.23 per cent.) The great industrial expansion which began about 1911, with its attendant demand for credit, helped push the rate well above 4 per cent, and it continually worked higher and higher until by the time the depression hit us in the 1930's, cities with the finest credit were paying 5½ and even 6 per cent for borrowed funds.

Starting about 1935, however, we moved into an era of controlled economy—a period of artificial controls, under which all economic actions were geared to combat the depression. The first objective was to make money plentiful and cheap. I shall not go through the various steps used to accomplish this, but the end result was the financing of huge federal deficits by the sale of US government bonds to the banks, thereby inflating credit to unheard of levels. Naturally, loan rates fell rapidly. That is the period, unfortunately, which most people use as a criterion for comparing interest rates, for today's businessman who is under 47 years of age has no actual working knowledge of the higher rates which preceded that period.

Some experts will tell you that this artificial method of combating depression would never have succeeded. Actually, we never really had a chance to find out, because starting early in the 1940's we had a major war to finance, followed by another, smaller war. In order for the government to finance these unusual expenditures as cheaply as possible, the "easy money" policy was not only continued, it was actually augmented. Those who remember the war loans of World War I will recall the first Liberty 3½'s, followed by 4's, 4¼'s, and finally the Victory Loan 4¾'s—an increasing rate for each successive loan as credit grew tighter under normal economic laws. During the 1940's, however, you will recall that each succeeding loan was at a lower rate of interest. This was easily done with money managed by treasury and federal reserve bank operations.

Actually, money was approaching the place where it earned little or no return. I recall an investor during that period who wanted to put $50,000 to work for a year—he needed the money for some payment on some specific day. I bought what he wanted and it paid him 0.2 per cent interest. Actually, that comes to less than 30 cents per day. I well recall his grimacing and saying he never thought he would live to see the day when it would take a capital investment of $50,000 to buy him one package of cigarettes and a morning newspaper.

The shooting finally ended, however, and when it did there was a lot of catching-up to do. Expansion was the order of the day. There were roads to be built, as well as schools, doubled-up families to be unscrambled, and defunct autos to be replaced with new ones. There was more money around than goods to buy, so prices rose dramatically. Suddenly we were face to face with price inflation, and responsible people knew it had to be checked before it started to feed on itself. The natural way was to remove the original cause—too easy credit conditions—or in other words, to restrain credit somewhat. And that is the period we are in now. Actually it started back at Christmas 1947, when the treasury and the federal reserve began to withdraw their support of the government bond market. But since you cannot pull down all the foundations at one fell swoop, it was done gradually. Just as the inflation, which really started in the 1930's, did not catch on until the late 1940's, so

the 1947 process of unwinding the inflation spiral did not really catch hold until a few years ago. That municipal bond index I spoke of continued to go lower and lower even after 1947, until in 1950 it reached a low for that immediate period of about 1½ per cent. In 1951 it hovered around 2¼ per cent. Since then it has moved toward higher interest rates until, as I said, it now stands at 3.23 per cent.

With election time approaching, you will soon hear politicians of both parties condemning what they call "tight money," but few of them will know of what they speak. In my opinion there is no choice between tighter money as reflected by higher interest rates and the ogre of inflation. Dearer money has an effect on all of us—no one can deny it. But as compared to inflation, it is the lesser of two evils. The latter always leads to disaster. It has been amply proved so many times elsewhere in the world that no qualification of that statement is needed.

## Present Outlook

Unless something totally unforeseen should develop, I doubt that we will ever return to the low rates of the 1950–52 period. On the other hand, there seems to be no reason why rates should again rise to the much higher earlier levels, for today, with high income taxes, the value of the tax-exempt municipal bond is augmented in investors' hands. In fact, a slowing up in the rate of borrowing could lower the rate by ¼ per cent—possibly more, for a period.

All I can say to you, therefore, is get yourself ready to pay whatever the going rate is when you borrow. If you do not, there are plenty of others who will, as that 2.46 billion dollar figure indicates, for not all borrowers are too concerned about the rate. Many of the borrowers—telephone companies, electric companies, finance companies—pass the rate along to the public, which does not care if it pays $87 or $89 a month to get that new car!

As investment bankers, we can do nothing about it. We can, however, suggest one way you water people can save a little on the rate. It applies to those of you who issue water revenue bonds (a water bond paid by the city out of general funds will always be only as good or as bad as the city's own credit). The answer is to raise your water rates to produce better coverage of the principal and interest charges on your debt. That better coverage gives you a better rating for your bonds. A better rating gets you a lower interest rate. The surplus created from the higher rates can be used to retire debt before maturity, thereby saving you money on interest you do not have to pay out. That saving also goes into surplus to retire still more debt. And so the circle continues, with all the benefits from the higher rates accruing in favor of those who pay them.

How much of a rate rise should you ask? It all depends on circumstances. Assume a hypothetical case: An income of $2,000,000, minus operating and other expenses of $1,500,000, leaves $500,000. This is to cover principal and interest charges, which, let us say, amount to $400,000 annually. Dividing 4 into 5 results in a debt coverage of only 1.25:1. Now, raise water rates 20 per cent, and income goes up $400,000, which passes right through to surplus, raising that figure from $500,000 to $900,000. That raises the debt coverage factor to 2.25:1. Obviously, this is a much finer credit risk, entitled to a much better rating and a lower interest rate.

That brings me back to the same old story which I guess must be tiresome to most of you—namely, we do not get enough for our water! It leaves me almost in the spot of a minister or priest. He has only one topic, too, and that's sin. Naturally he has to be against it. His problem is to try to say it differently every Sunday, hoping some listener will get ideas that will help him.

The water business presents itself to me as sort of a paradox. At first I see it elevated on a very high pedestal—the pedestal of supreme confidence, like the confidence of a child in its mother's love or your confidence in the surgeon who snuffs out your consciousness before he makes you well. So the public is confident it will have pure water, readily at hand, and it gets it.

Then I look again and get confused because I can't see you at all. What happens in your city? Everyone knows the mayor with his name and picture in the papers all the time, or the park department—they convert a couple of empty lots into a playground or add a few shrubs, call it a park, and get their names plastered in the papers—or the school department, police, fire, highway departments—it is always the same. But what about the water department? The only way you get publicity is if the Lord does not send enough rain, and then the papers print pictures of your rapidly dwindling reservoirs. This happens rarely, for you all work so hard and plan so far ahead. With other city departments, the people expect little and go into ecstasies when they get something. With you, they take everything for granted.

## Importance of Water

I know much progress has been made in getting more equitable rates—all steps in the right direction. But how can we bring home to the people the fact that if the average water bill were doubled it would still be the cheapest bill we pay and for our most precious commodity? In fact, water is our most precious natural resource, without which all other natural resources would be worth peanuts.

It is too bad the industry cannot buy TV time and magazine space and put the product across as the motor companies do. They condition our minds to buy their cars, and we do. They stick fins out the rear, make them too low to get into easily, too long for our garages, too wide for the doorways, too expensive on fuel consumption. But we buy them. Then to top it off, they make us their advertising medium, plastering their name all over our car and making us pay for it besides. And to think the average car costs more than the water bills the average man pays during his entire lifetime as head of a household. Everyone likes water, everyone wants it, everyone has to have it, but it does seem that often we almost give it away!

I enjoyed reading John Murdoch's speech made in St. Louis (*1*). I thought he brought out some overlooked points. He said it was not until around 1900 that people knew epidemics like typhoid could come from impure water. And what happened? You nice people set about correcting the trouble, and the public has forgotten all about it.

Murdoch also said that the reason for the first public water system was to aid in fighting fires. That's still a pretty important reason, but do the people realize it? Just what is the cost of water compared to what we pay for fire insurance? I thought I could find some statistics that would tell me how

much fire insurance was carried in a given city or town, but none were available. We all know, however, that without water to fight fires, our fire insurance rates would be trebled. I did some spot checking on my own to determine the total fire insurance bill of a particular community. On inquiry, I found fire insurance carried at six times the assessed valuation, at five times, four times, three times, and never less than two times. All right, let us say I went to all the wrong places. If the actual average were only twice the assessed value in the city I spot-checked, the combined insurance bill of its inhabitants would rise \$432,000 if the hydrants were removed. How much do they pay to save that \$432,000? They pay less than \$50,000, which is not even added to their water bills, as the company bills them only for household use. The standby hydrant charge is put into the general budget by the city fathers and spread on the tax bill the same as any other expense. (Incidentally, the total water company collection in that city is less than \$500,000 a year. Comparing that figure to \$432,000 rather startles you.)

On the night of Apr. 3, just before retiring, I said half aloud to my family, "I wish I could think of some helpful idea to give to the water works people in Atlantic City next month whereby their product would not be taken so much for granted." Next morning when we arose there was no water. During the night a main had broken, and 4,000 homes were bone dry. What a scurry! No baths, no shaving, and, most important, no coffee. Fortunately, it had snowed about 3 in. during the night, and my younger son, home from college on a visit, thought it quite a lark to take an old sugar scoop and skim off snow with which to make some coffee—that is, until he found how many pails of snow it takes to fill a couple of coffee cups. Turning to me he said, "Well, Dad, there's the answer you wanted last night. Just tell the water departments to turn off the water 1 day a month, without notice—believe me, the people would appreciate it when it was turned on again."

I don't know that I can recommend such drastic action, but at least it is an idea.

## Reference

1. Murdoch, J. H. 75 Years of Too Cheap Water. *Jour. AWWA*, **48**:925 (Aug. 1956).

# An Evaluation of Water Utility Earnings

## *Panel Discussion*

*A panel discussion presented on May 16, 1957, at the Annual Conference, Atlantic City, N.J.*

## Introduction—*Louis R. Howson*

*An introductory statement by Louis R. Howson, Partner, Alvord, Burdick & Howson, Chicago, Ill.*

THIS discussion is to be devoted to one of water works' most important problems. That problem is revenues.

Water requirements are continuously expanding, both as to the quantity of water used and as to the standards of quality of the delivered water. And the dollar cost of meeting these requirements is growing due to inflation.

The water works industry has expended, to the present time, some twelve billion dollars in its development. Largely as the result of its own rapid growth combined with the decreasing purchasing power of the dollar, many water works have expended as much for new construction in the past decade or two as in their entire prior existence, which in most cases is some 50 years more or less.

Water works have always been built and paid for by those who use the service. In that respect they are unique in water resources utilization. It is obvious, therefore, that water works construction, as well as operation, must be financed either directly or indirectly through revenues.

The panel members who are participating in this discussion are representatives of some of the best operated water utilities in the country. Several panel members are from cities where other utilities, such as electric or gas, are also publicly operated.

This panel discussion will deal with several questions. Included among them are:

1. Are water works earnings adequate and, if not, who has the primary responsibility for that situation?

2. Are new consumers paying their share of the revenues?

3. What should be the policy with respect to charges for water sold inside and outside of the corporate limits?

4. What is the relationship between per capita revenues in water and those in other utilities, such as electric or gas?

5. What is the relationship between revenues and investment in water and other utilities?

6. How can water utilities be assured of revenues adequate to maintain the high quality of service to which the public has become accustomed?

7. How can they secure the funds necessary to expand the facilities that are needed?

These are some of the important questions that will be discussed by the various members of this panel.

## Michigan—*Claud R. Erickson*

*A paper presented by Claud R. Erickson, Mech. Engr., Board of Water & Elec. Light Comrs., Lansing, Mich.*

In 1954, an analysis was made of 123 Michigan water works systems to obtain operating and physical statistics of the water production facilities in the state. There are over 400 separate water departments or authorities in Michigan, and these departments serve villages, cities, or districts having groups of customers whose populations range from less than 1,000 to over 2,000,000. The water is secured from wells and lakes or is purchased from some other water department.

Stated another way, these figures also represent the number of years required to turn over the capital invested. When this is compared with the amount of capital required for other businesses in any community the conclusion is readily reached that great care should be exercised in planning additions to water works systems because of the very slow turnover. It is interesting to compare this fact with data obtained from other business (Table 1).

TABLE 1

*Capital Required per Dollar of Annual Revenue for Various Businesses*

| | | | |
|---|---|---|---|
| Grocery (retail) | $0.09 | Hardware (retail) | $ 0.28 |
| Liquor (retail) | 0.17 | Dry goods (retail) | 0.30 |
| Drug | 0.20 | Lumber and building supply | 0.30 |
| Gas station | 0.20 | Men's clothing | 0.34 |
| Bakery (retail) | 0.20 | Furniture (retail) | 0.44 |
| Appliance (retail) | 0.21 | Jewelry (retail) | 0.48 |
| Restaurant | 0.22 | Manufacturing | 0.60 |
| Shoe (retail) | 0.23 | Motel | 2.50 |
| Women's ready-to-wear (retail) | 0.23 | Electric generating system | 5.00 |
| Sporting goods (retail) | 0.25 | Water supply system | 10.00 |

### Investment Relationships

One of the most interesting relationships revealed by the study was the amount invested in the various systems per dollar of annual revenue from service. As would be expected, the smaller the system the greater the investment required per dollar of annual revenue.

Of 37 systems which were serving populations of 10,000 and over, the investment per annual dollar of sales was $9; in 86 systems serving populations under 10,000, the investment was $15 per dollar of annual sales.

A review of the water supply systems data submitted in 1954 indicated that many of the smaller water systems had no record available on the amount invested in their systems. These publicly owned properties usually had difficulties in maintaining good service principally because nothing was being collected for a depreciation charge which, on the average, should be approximately $0.20 of each revenue dollar.

State regulating commissions usually limit private water companies to a low

provision for depreciation, on the order of 1.5 per cent. Publicly owned water systems can use a more realistic figure of about 2.5 per cent. This will result in and make available a good source for construction funds.

It cannot be emphasized too strongly that this investment figure of $10 per dollar of water revenue reflects the fact that most systems are not charging enough. If rates were doubled, the investment ratio would be the same as that for electric generating utilities—$5 per dollar of revenue.

Many thinking people in the water works industry have asked why electric utilities collect more for service than do water utilities. The answer lies again in the dollar investment per dollar of sales of these two utilities. If the electric utility collects 5 per cent for depreciation and 6 per cent as interest on capital invested (the term "profit" may be substituted or "net income transferred to surplus or city equity"), a total cash flow of 11 per cent results. On a $5 investment, this would amount to $0.55 of each revenue dollar, leaving $0.45 for operating and maintenance costs and local, state, and federal taxes. In an average water system, the depreciation charge would be 2 per cent and the net income transferred to surplus, 5 per cent—a total of 7 per cent on the capital invested in the system. Based on a $10 investment charge, $0.70 of each revenue dollar should be collected for these two items of cost of service, leaving $0.30 for operating and maintenance costs and local, state, and federal taxes for a water utility. Very few systems measure up to this method of analysis and therein lies the basic cost difficulty.

## Cash Flow

The term cash flow is used to indicate the total of net income which can be transferred to surplus plus the depreciation charges. The sum of these two items is the amount that can be used for making additions to the production or distribution facilities of publicly owned systems. In the privately owned systems the cash flow is reduced by the amount of the dividends.

## Rate Schedule

Another factor that may hamper accumulation of funds for maintenance and expansion is a reluctance to include in the water rate charges for known or anticipated improvements and extensions. It should be more economical to generate internally sufficient capital to make these expenditures than to rely on externally generated capital—that is, bond issues.

It should be the responsibility of the water superintendent or general manager of the water utility to initiate and urge properly the adoption of a rate schedule that will produce sufficient funds for good and adequate service.

Long-range planning is a must for any growing water system. In many systems these decisions are made by elected officials. It has been the custom to elect officials for a 2-year term, but the present trend is toward 4 years. With this change in political thinking, some of the hesitancy in making decisions may be corrected. Decisions of this nature are made best by an appointed board or commission which has complete political autonomy.

## Service Classes

The AWWA water rates manual (*1*) uses for the various types of customers the designations "wholesale," "intermediate," and "domestic." The term wholesale is a misnomer and may be an obstacle to obtaining adequate revenues. These days, everyone wants to buy wholesale, without dis-

crimination. The terminology for the classes of service in the electric industry is more descriptive and more easily understood by the rate payers. These classifications are usually "residential," "commercial," "industrial," and "municipal." It is suggested that the water industry also use this terminology in publications and rate determinations.

Many of the smaller systems do not even attempt to classify their customers, lumping all sales in one general gross revenue account. Prudent management should know the sources of revenue, and the consumption by the various classes of customers.

Most people want to pay adequately for the service supplied them. There are many more items that effect water rates than those indicated above and the problem can be presented by many other methods of analysis. In many instances, poor service results when those in charge lack the courage to inform properly the water users of the financial and operating problem confronting the community or district.

A well informed body politic will usually respond intelligently to an equitable solution of a community problem when it is properly presented; this is particularly true in problems of water service and rates.

## Reference

1. *Water Rates Manual—AWWA M1.* Am. Wtr. Wks. Assn. New York (1957).

## Dallas—*Henry J. Graeser*

*A paper presented by Henry J. Graeser, Supt., Water Works, Dallas, Tex.*

The earnings of water utilities as compared to the other utility services has been a subject worthy of thorough study for some time. With all utilities the problem of supply has a direct effect on the investment required and the relative earning power of the utility. An electric company which must produce its power in a steam generating plant will reflect a different capital and operating-expense structure than the hydroelectric plant. A water supply which must be transported long distances through pipelines to support a metropolitan area has a large investment per customer and smaller earning ability than the utility located on a river. Despite these factors, however, there are some most pertinent trends. It seems advisable to include in this study a fourth utility common to all municipalities—that of sewerage service. In Dallas, these two utilities operate as a single department and the services are billed as a single rate. The water rate for the city is entitled a water and sewerage rate and as long as a business or home has both services, a single bill is rendered computed on the basis of water consumed. The combined rate is calculated to support both utilities in their entirety, including the capital charges of each required to meet the growth of the city.

The rather severe drought in this area, coupled with a shortage of supply in past years, necessitated emergency measures by the city to assure a safe and adequate supply. Despite stringent rationing on the use of water for lawn sprinkling, however, the past fiscal year, ending on Sep. 30, 1956, broke all records for consumption and income. From the balance sheet for this year it can hardly be said that present rates are inadequate. Since the last rate increase in Dallas in 1951, the revenue has more than kept pace with

TABLE 2

*Income Statement of Dallas Water and Sanitary Sewer Department, Reported on Cash Basis**

| Item | Sewer Revenue | Water Revenue | Total Water and Sewer Revenue | % |
|---|---|---|---|---|
| *Operating Revenue* | | | | |
| Water sales and sewer services | $4,177,315 | $7,897,852 | $12,075,167 | 97.03 |
| Other water and sewer revenue | 118,027 | 251,615 | 369,642 | 2.97 |
| *Total* | 4,295,342 | 8,149,467 | 12,444,809 | 100.00† |
| *Operating Revenue Deductions* | | | | |
| Source of water supply | — | 233,636 | 233,636 | 4.53 |
| Purification | — | 808,736 | 808,736 | 15.66 |
| Water pumping | — | 600,129 | 600,129 | 11.62 |
| Transmission and distribution | — | 1,007,773 | 1,007,773 | 19.52 |
| Customer accounting and collecting | 260,127 | 491,902 | 752,029 | 14.58 |
| Administrative and general | 251,757 | 476,074 | 727,831 | 14.11 |
| Operation and maintenance of sanitary sewer system | 624,977 | — | 624,977 | 12.12 |
| Sewage pumping | 73,015 | — | 73,015 | 1.42 |
| Sewage treatment | 332,165 | — | 332,165 | 6.44 |
| *Total* | 1,542,041 | 3,618,250 | 5,160,291 | 100.00‡ |
| *Net Operating Revenue* | 2,753,301 | 4,531,217 | 7,284,518 | 100.00§ |
| *Nonoperating Receipts* | | | | |
| Water and sewer service connections | 169,891 | 263,741 | 433,632 | |
| Water and sewer main extension | 342,143 | 446,383 | 788,526 | |
| Sale of Equipment | — | 21,458 | 21,458 | |
| *Total* | 512,034 | 731,582 | 1,243,616 | |
| *Nonoperating Disbursements* | | | | |
| Refunds and miscellaneous | 64,198 | 73,780 | 137,978 | |
| *Net Nonoperating Receipts* | 447,836 | 657,802 | 1,105,638 | 100.00‖ |
| *Net Profit, 1955–56* | $3,201,137 | $5,189,019 | $ 8,390,156 | 100.00# |

Reconciliation of Cash Balance

| Item | Sewer Revenue | Water Revenue | Total Water and Sewer Revenue | % |
|---|---|---|---|---|
| *Deduct: Other Cash Disbursements* | | | | |
| Amortization of long-term debt | $2,381,263 | $3,371,710 | | |
| Capital outlay | 217,982 | 1,012,492 | | |
| Transfer to construction account | 281,822 | 417,929 | | |
| Transfer to developers refund account | 14,252 | 1,666 | | |
| Net additions to stores inventory | — | 78,232 | | |
| *Total* | 2,895,319 | 4,882,029 | $ 7,777,348 | |
| *Net Increase in Cash, 1955–56* | $ 305,818 | $ 306,990 | $ 612,808 | |
| Add: Cash Balance, Oct. 1, 1955 | | | 343,421 | |
| *Cash Balance, Sep. 30, 1956* | | | $ 956,229 | |

* For the fiscal year ending Sep. 30, 1956.
† Sewer revenue was 34.52 per cent of the total and water revenue 65.48 per cent.
‡ Sewer revenue deductions were 29.88 per cent of the total and water revenue deductions 70.12 per cent.
§ Sewer revenue was 37.80 per cent of the net operating revenue and water revenue 62.20 per cent.
‖ Sewer revenue was 40.50 per cent of net nonoperating receipts and water revenue 59.50 per cent.
\# Sewer revenue was 38.15 per cent of net profit and water revenue 61.85 per cent.

the growth of the area and increasing capital charges and operating expenses necessary to support both the water and sewerage utilities. This has occurred despite several millions of dollars required to meet the development of emergency supplies to augment dwindling impounded storage. Table 2 shows the results of operation for 1956. Through machine billing, the entire year's consumption has been separated according to the rate blocks in which water was consumed (Table 3). Accounts were also rendered with the sewer revenue segregated from water revenue. Records of expenses and capital charges are kept separately and, after this special run, it was possible to reconstruct the actual operating expenses and income of each utility. It is interesting to note that the rate as calculated adequately distributes the charge for service to each utility and against its individual operating expense and capital charges, so that an almost equal amount of surplus could be allocated to each at the end of the

TABLE 3

*Water and Sewer Revenue by Consumption Blocks, Dallas**

| Item | Number of Bills | Water Consumption Billed *1,000 gal* | Sewer Revenue | Water Revenue | Total Revenue |
|---|---|---|---|---|---|
| *Regular Billings* | | | | | |
| Consumption Block: | | | | | |
| 0–1,000 gal | 75,085 | 50,818 | $ 47,557 | $ 91,256 | $ 138,813 |
| 1,000–5,000 gal | 663,205 | 2,026,729 | 676,989 | 1,089,830 | 1,766,819 |
| 5,000–100,000 gal | 1,147,268 | 17,124,919 | 2,694,434 | 5,176,804 | 7,871,238 |
| 100,000–500,000 gal | 16,656 | 3,107,286 | 285,664 | 674,696 | 960,360 |
| 500,000 gal and over | 1,938 | 2,913,994 | 213,559 | 384,969 | 598,522 |
| Sewer only | 3,325 | — | 3,213 | — | 3,213 |
| Other miscellaneous billing | | 10,422 | 2,708 | 4,600 | 7,308 |
| *Total* | 1,907,477 | 25,234,168 | 3,924,124 | 7,422,155 | 11,346,279 |
| *Industrial Billings* | | | | | |
| Consumption Block: | | | | | |
| 0–1 mil gal | 56 | 46,310 | 4,946 | 10,532 | 15,478 |
| 1–2 mil gal | 281 | 407,076 | 29,531 | 63,806 | 93,337 |
| 2 mil gal and over | 419 | 2,284,879 | 98,265 | 245,625 | 343,890 |
| *Total* | 756 | 2,738,265 | 132,742 | 319,963 | 452,705 |
| *Cities* | | | | | |
| Filtered water | 98 | 662,157 | — | 111,651 | 111,651 |
| Raw water | — | 2,764,859 | — | 44,083 | 44,083 |
| Sewer only | 48 | — | 120,449 | — | 120,449 |
| *Total* | 146 | 3,427,016 | 120,449 | 155,734 | 276,183 |
| *Total All Billings* | 1,908,379 | 31,399,449 | $4,177,315 | $7,897,852 | $12,075,167 |

* For the fiscal year ending Sep. 30, 1956.

The rate for water and sewerage service (Table 4) has a flat step after 5,000 gal to 100,000 gal, which was calculated to give no benefit of decreased rate for lawn sprinkling and

air conditioning in the summer. It is these uses which have created the heavy demand of peak summer loads, with the accompanying capital charges for the facilities needed to satisfy them. Of 1,907,000 bills rendered in the fiscal year to regular billing customers, 1,147,268 of them fell within the 5,000–100,000 rate block. The bulk of the annual income was also derived from this rate block as might be expected.

TABLE 4

*Water Rates at Dallas**

| Amount Consumed—*gal* | | Rate per 1,000 gal |
|---|---|---|
| **Water and Sewerage Service** | | |
| First | 1,000 | $1.80 † |
| Next | 4,000 | 0.45 |
| Next | 95,000 | 0.35 |
| Next | 400,000 | 0.29 |
| Next | 500,000 | 0.25 |
| Next | 1,000,000 | 0.21 |
| Next | 1,000,000 | 0.17 |
| All over | 3,000,000 | 0.16 |
| **Water Service Only** | | |
| First | 1,000 | $1.00 † |
| Next | 4,000 | 0.30 |
| Next | 95,000 | 0.23 |
| Next | 400,000 | 0.20 |
| Next | 500,000 | 0.17 |
| Next | 1,000,000 | 0.14 |
| Next | 1,000,000 | 0.125 |
| All over | 3,000,000 | 0.12 |

* For consumers within city.
† Minimum bill.

The industrial billings illustrate that Dallas is not a big industrial area as far as water consumption is concerned. The eleven suburban communities around Dallas, which are also served, have not at this time exerted a serious demand on the city water system, and a commensurately small part of revenue derives from these sources.

## Comparison With Other Utilities

To compare water and sanitary sewerage utility operations with various light and power companies, fiscal reports were obtained on both private and municipally owned companies. Only one gas company was included because it was found that the companies on which data were available paid such a high price for gas to their own producing companies that their actual capital investment was disguised. In order to make the utilities comparable, taxes and depreciation as shown in each individual statement were deleted and all of the utilities placed on a gross property valuation as nearly as possible. Table 5 illustrates this comparison in detail and pertinent factors are illustrated graphically by Fig. 1. The Dallas Water Department has a gross plant valuation in the sanitary sewerage system of $48,614,000, which gives a plant investment per customer of $307. The water facilities of the city have a

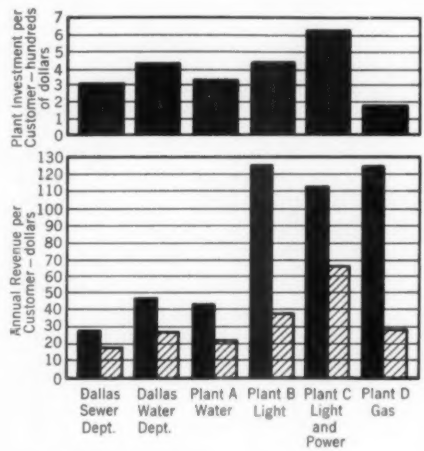


**Fig. 1. Comparison of Operations of Various Utilities, 1955–56**

*Comparisons are of same operations summarized in Table 5. In revenue section, solid bars show gross revenue and shaded bars, net. Plants are on a comparable basis with depreciation omitted.*

total plant investment of $72,579,837 for a plant investment per customer of $422. In Fig. 1, Plant *A*, which is a municipally owned out-of-state water company, has a plant investment per customer of $328, which reflects a source of supply developed at less expense than that of Dallas. The same municipality had, in its city owned light company, a plant investment of $437 per customer. Plant *C*, which is a privately owned Texas light and power company, has a plant valuation of $134,575,993 with a top plant investment of $628 per customer. It would seem that two examples of the power company, one municipally owned and one privately owned, are contrary to the contention that the water utility always has the higher plant investment per customer. Taking Plant *D*, the municipally owned gas company for an example, it can be seen that plant investment is low—$184 per customer—compared to the electric, water, and sewerage utilities. This, however, evidently represents investment in the distribution system, because here, production facilities are reflected in operating expenses only.

As shown in Fig. 1, the water and sewerage departments of Dallas are earning a gross revenue per customer of $27.11 per year for sewerage and $47.40 per year for water. The other municipal water company (Plant *A*) had a gross of $43.05, but both the light company (Plant *B*) and the power and light company (Plant *C*) earned nearly three times as much on a greater investment than the water or sewerage facility. The gas company, before operating expenses, shows a gross revenue comparable to the electric utilities. After operating expenses are taken into consideration, however, the water utili-

TABLE 5

*Comparison of Operations of Various Utilities* for the Fiscal Year 1955–56*

| Item | Dallas Sanitary Sewer Dept. (158,421)† | Dallas Water Dept. (171,913) | Water Co. *A* (114,214) | Light Co. *B* (168,309) | Power and Light Co. *C* (214,128) | Gas Co. *D* (146,895) |
|---|---|---|---|---|---|---|
| Gross plant valuation | $48,614,481 | $72,579,837 | $37,438,018 | $73,503,989 | $134,575,993 | $27,078,008 |
| Plant investment per customer | 307 | 422 | 328 | 437 | 628 | 184 |
| Gross operating revenue | 4,295,342 | 8,149,467 | 4,916,776 | 22,065,500 | 38,057,045 | 18,771,336 |
| Taxes (or equivalent) | — | — | — | 961,167‡ | 13,735,751 | 392,590‡ |
| Gross operating revenue less taxes | 4,295,342 | 8,149,467 | 4,916,776 | 21,104,333 | 24,321,294 | 18,378,746 |
| Average gross revenue per customer after taxes: | | | | | | |
| Annually | 27.11 | 47.40 | 43.05 | 125.39 | 113.58 | 125.12 |
| Monthly | 2.26 | 3.95 | 3.59 | 10.45 | 9.47 | 10.43 |
| Operating expense | 1,542,041 | 3,618,250 | 2,529,549 | 14,621,531 | 10,309,803 | 14,126,526 |
| Difference between revenue and operating expense | 2,753,301§ | 4,531,217§ | 2,387,227§ | 6,482,802‖ | 14,011,491‖ | 4,252,220‖ |
| Average operating revenue per customer: | | | | | | |
| Annually | 17.38 | 26.36 | 20.90 | 38.52 | 65.43 | 28.95 |
| Monthly | 1.45 | 2.20 | 1.74 | 3.21 | 5.45 | 2.41 |

* All municipal except Company *C* which is a private operation.
† Figure in parentheses gives number of customers with exception of that given for Dallas Water Dept., which refers to number of meters in service.
‡ City tax equivalent.
§ No taxes or depreciation shown.
‖ No depreciation shown.

ties are presented in a bit more favorable light, but the privately owned light and power company still shows earnings three times those of the municipal water company, and about 2.5 times those of the Dallas water works. The gas company ends in about the same category as the water utility. Table 5 shows that the privately owned light and power company had an operating expense, exclusive of taxes, of $10,309,000 compared with that of the Dallas Water Department of $3,618,250. Both of the power companies selected are steam facilities, although the municipal light company does buy some hydroelectric power. It would appear then, at least from this analysis, that the water works and even the sewerage utility field have a considerable edge (in the examples cited) in plant investment and operating expenses, although the industry fails to earn anywhere near the same return on investment. Granted that the electric utilities have a commodity to sell which finds need in today's home life from television to air conditioning—all of which bring bodily comfort and pleasure—electric power is not as essential as water to urban life. Seemingly, power is a more salable item than water. Coupled with low rates, as an irksome obstacle, is the municipality's notorious inability to advertise or explain its situation to the public. What is publicity for a franchise utility is propaganda when it issues from city hall.

## Demand Charges

The electric utility in the Southwest has a load factor equally as bad as Dallas' summer sprinkling and air-conditioning load. They, too, have the problem of idle plant capacity during 8 months of the year, which probably accounts for their unusually high plant investment per customer. The electric utility, however, has a demand meter and demand rates, and they sell their product through advertising. In Dallas for example, any house which is air conditioned and has a total connected load of more than 3 tons of air conditioning has a class rate for the summer which is higher and not lower for the power consumed over the winter base. The use of demand meters in factories and commercial buildings also establishes a more equitable base for return. Demand charges must be one of the major factors involved in the water works industry's poor earning capacity. Lawn-sprinkling systems are being installed in Dallas at an alarming rate and the potential demand of these systems on an 8-in. and 6-in. grid is a matter of deep concern. Industrial load, as has been shown is not large, but, nevertheless, industry can exert a rather considerable load at the wrong time. The instantaneous demand of industry in this city, however, is small compared to that of the lawn-sprinkling problem coupled with air conditioning and other summer water uses. One of the first steps in correcting earning capacity, and one which can be applied gradually, is the demand charge type of billing which will either require payment of a minimum bill sufficient to carry the investment or require the use of water to be spread to off-peak periods. The modern underground sprinkler system with its time clock fits this type of legislation admirably. A demand meter is needed, too, for installations not so equipped in order that the charge be equitably assessed against a domestic account having meter sizes larger than 1 in.

## Public Relations

It should be added, however, that "selling" the utility and what is behind it is as essential to the demand rate as

it is to any other practice. Those manufacturers who, in national advertising in popular magazines, have attempted to convey to the public the cost of serving water are to be commended. This is the type of help which can be given by industry to the water utility people. For Dallas, the old adage "It is an ill wind that blows no good," has certainly been true. Before 1950, it was very difficult to find space in the local newspaper for news items concerning the water department. Out of the drought, however, came an awakened interest in the water supply problem and it has now been front page news for nearly 7 years. In the course of the drought, plans for the future have been presented and costs for such future plans have been brought home to the consumer through repeated headline coverage. Although much of the publicity was not at all pleasant, it has achieved one purpose in informing the public that water is expensive—especially in the Southwest.

## Growth in Dallas

As previously stated, utility earnings in Dallas are adequate at the present time. Figure 2 which illustrates the growth of Dallas' water and sewerage utility combined since the end of World War II includes the combined source and disposition of funds for the Department of Water and Sewerage. At the end of the war, Dallas had an estimated total plant valuation of approximately $26,000,000. At the end of fiscal year 1945–46, this had been increased to $30,577,000 with a plant investment per customer of $350 for both utilities. In 1946–47, 1948–49, and 1951, rate increases were approved. These increases were necessary to meet short-term capital requirements for the rapid postwar expansion. Income from connection charges in 1949–50 reached a high in the postwar period. This figure, however, disguises somewhat the fact that the contributions in aid of construction were deposited in the water works operating fund, whereas the actual construction work was done from bond funds available to the department in that year. It can be seen that in the years following, through 1952–53, this surplus was more than used up by cash capital outlay in budgeted codes so that in 1954–55 expenditures only slightly exceeded the total income. It is interesting to note that operating expenses have more than quadrupled since the end of the war and debt service is five times the figure it was at the end of the war.

## Plant Investment

The fact which seems to be of major concern is that plant investment per customer is double what it was at the end of the fiscal year 1945–46, and the total gross plant value, without depreciation, has mounted to four times that of 1945–46. This, of course, represents future capacity, but it also represents the increased cost of finding new sources of supply in the Southwest. Indications seem to be that this plant investment per customer figure will increase rather than decrease as the city continues to grow. It is an interesting fact, too, that a large part of this capital expense has been necessitated by expansion of distribution facilities to meet the peak load accompanying this growth. Dallas has an area now of approximately 240 sq miles as compared with approximately 44 sq miles in the 1945–46 period. This should illustrate the distribution problem and indicate why it has been such a major item of expense. To date, supply has been relatively inexpensive and the existing sources have employed gravity flow. The next de-

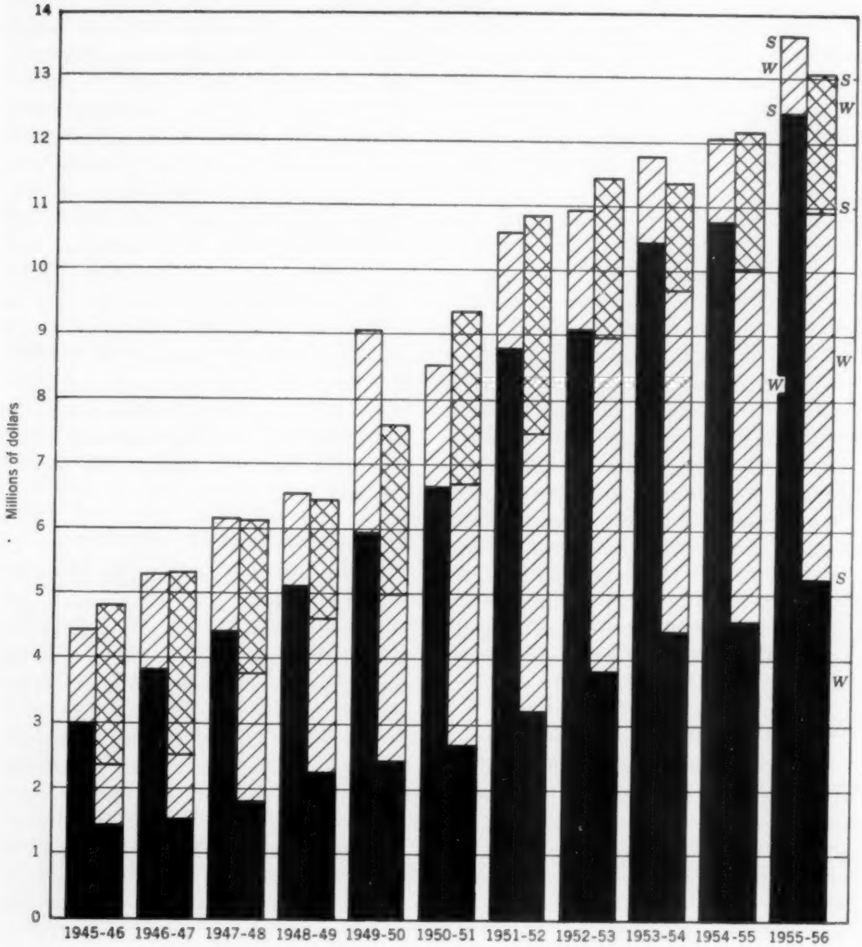


**Fig. 2. Source and Disposition of Funds at Dallas**

*In left bar of each double bar, solid portion indicates income from sale of water and sewerage services; shaded portion, nonoperating receipts in form of connection charges and deposits. In right bars solid portion represents operating expenses; shaded part, debt service or long-term capital requirements; cross hatched portion, capital outlay in cash from earnings or income. Utilities built after 1953 (entire cost paid by developers) are not shown as income, but are included in plant value. In 1955–56 bars, letters* W *and* S *designate funds and costs for water and sewerage services, respectively. Gross plant value in millions of dollars for the periods shown is, consecutively (beginning with 1945–46), 30.577, 35.049, 41.270, 47.423, 63.363, 70.831, 83.048, 93.098, 103.28, 113.273, and 121.194. Plant investment in dollars per customer for the same periods was: 350, 380, 411, 439, 542, 546, 598, 637, 660, 686, and 705.*

velopment in supply, however, will necessitate pumping water approximately 43 miles, at a cost nearly four times that involved in present supply methods.

## Expansion and Earnings

It is certain that the problem confronting Dallas is no more serious than that in other cities where expansion is imminent and earnings are presently only enough to provide and maintain the existing source of supply and distribution. The question that is being discussed, then, takes on added seriousness when one considers the problem of additional expansion and what it is going to mean in the way of expense against the earnings which can be anticipated. For example, in planning for Dallas' next step in supply, a 72-in. pipeline is involved; that pipeline, of course, has a capacity which engineering economics dictate must be provided at this time.

## Planning for Future Needs

In studying Dallas' water requirements, the policy has been adopted that the municipal system must supply Dallas County. On this basis requests have been made of the State Board of Water Engineers for water permits and allocations which will permit ultimate development of all available sources for the county as a whole. In return, Dallas pledges to sell water to adjoining smaller communities at a fair price, representative of their share of the expense. In approaching this problem, it was necessary first to determine what the county population would be and then, excluding those communities which have developed adequate supplies of their own, to determine just what would be the demands on Dallas' water system. A study was made of the growth of the Dallas area. This was approached on the basis of present industrial and commercial pace. The growth of these enterprises was evaluated from the standpoint of the number of people necessary to service the increased working force engendered by the industrial and commercial expansion. Figure 3 shows the results of the study, which estimates more than 2,400,000 people in Dallas County by the year 2000. Considering the cities with which Dallas presently has water

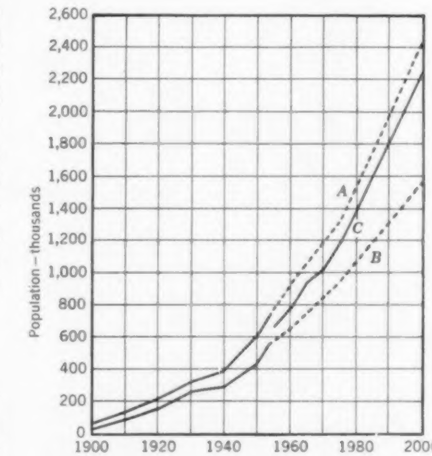


**Fig. 3. Population Projection of Dallas and Dallas County**

*Curve* A *is for Dallas County,* B *for Dallas, and* C *the population to be supplied with Dallas water. Projected portions shown in broken line.*

contracts, and those with which contracts are anticipated, 1980 estimates indicate that the city must serve 1,400,000 by that year and in the vicinity of 2,250,000 people by the year 2,000. A plan has been developed which will assure a program of construction of the impounding reservoirs necessary to meet this growth. To plan the distribution system, however, the growth of each of the communities involved as

well as that of the incorporated area of Dallas have been studied in detail.

A map of urban communities, subdivided to correspond as nearly as possible with census areas was prepared and water service areas and major transmission lines were superimposed on these. Projections have been made of populations through the year 1980 tion of impounded supply and that of plant and distribution capacity.

The $64 question—yet unanswered—is a projection of the expenses involved in meeting the demand. Table 6 illustrates a projection of water and sewer operating income and expenses for the city through 1984. Admittedly, estimates after 1980 are a straight line

TABLE 6

*Projection of Water and Sewer Operating Income and Expenses at Dallas*

| Fiscal Year* | Water and Sewer Sales, City of Dallas | Water Sales, Dallas County | Sewer Revenue, Dallas County | Miscellaneous Income | Total Operating Income | Operating Expenses | Net Income† |
|---|---|---|---|---|---|---|---|
| 1956 | $ 11,196,000 | $ 153,000 | $ 160,000 | $ 258,000 | $ 11,767,000 | $ 5,115,000 | $ 6,652,000 |
| 1957 | 11,746,000 | 222,000 | 160,000 | 270,000 | 12,398,000 | 5,391,000 | 7,007,000 |
| 1958 | 12,058,000 | 309,000 | 168,000 | 277,000 | 12,812,000 | 5,574,000 | 7,238,000 |
| 1959 | 12,456,000 | 385,000 | 169,000 | 286,000 | 13,296,000 | 5,787,000 | 7,509,000 |
| 1960 | 12,743,000 | 467,000 | 171,000 | 293,000 | 13,674,000 | 5,955,000 | 7,719,000 |
| 1961 | 13,229,000 | 520,000 | 172,000 | 304,000 | 14,225,000 | 6,197,000 | 8,028,000 |
| 1962 | 13,721,000 | 593,000 | 173,000 | 316,000 | 14,803,000 | 6,450,000 | 8,353,000 |
| 1963 | 14,219,000 | 657,000 | 174,000 | 327,000 | 15,377,000 | 6,702,000 | 8,675,000 |
| 1964 | 14,723,000 | 770,000 | 175,000 | 339,000 | 16,007,000 | 6,978,000 | 9,029,000 |
| 1965 | 15,130,000 | 895,000 | 176,000 | 348,000 | 16,549,000 | 7,216,000 | 9,333,000 |
| 1966 | 15,542,000 | 950,000 | 177,000 | 357,000 | 17,026,000 | 7,426,000 | 9,600,000 |
| 1967 | 16,061,000 | 1,011,000 | 178,000 | 369,000 | 17,619,000 | 7,686,000 | 9,933,000 |
| 1968 | 16,586,000 | 1,077,000 | 179,000 | 381,000 | 18,223,000 | 7,951,000 | 10,272,000 |
| 1969 | 17,116,000 | 1,150,000 | 181,000 | 394,000 | 18,841,000 | 8,222,000 | 10,619,000 |
| 1970 | 17,652,000 | 1,255,000 | 183,000 | 406,000 | 19,496,000 | 8,508,000 | 10,988,000 |
| 1971 | 18,193,000 | 1,332,000 | 184,000 | 418,000 | 20,127,000 | 8,785,000 | 11,342,000 |
| 1972 | 18,698,000 | 1,409,000 | 185,000 | 430,000 | 20,722,000 | 9,045,000 | 11,677,000 |
| 1973 | 19,187,000 | 1,456,000 | 185,000 | 441,000 | 21,269,000 | 9,286,000 | 11,983,000 |
| 1974 | 19,744,000 | 1,510,000 | 186,000 | 454,000 | 21,894,000 | 9,559,000 | 12,335,000 |
| 1975 | 20,308,000 | 1,564,000 | 186,000 | 467,000 | 22,525,000 | 9,836,000 | 12,689,000 |
| 1976 | 21,074,000 | 1,660,000 | 187,000 | 485,000 | 23,406,000 | 10,220,000 | 13,186,000 |
| 1977 | 21,782,000 | 1,771,000 | 188,000 | 501,000 | 24,242,000 | 10,584,000 | 13,658,000 |
| 1978 | 22,586,000 | 1,861,000 | 189,000 | 519,000 | 25,155,000 | 10,982,000 | 14,173,000 |
| 1979 | 23,197,000 | 1,981,000 | 190,000 | 534,000 | 25,902,000 | 11,308,000 | 14,594,000 |
| 1980 | 23,882,000 | 2,087,000 | 190,000 | 549,000 | 26,708,000 | 11,659,000 | 15,049,000 |
| 1981 | 23,882,000 | 2,087,000 | 190,000 | 549,000 | 26,708,000 | 11,659,000 | 15,049,000 |
| 1982 | 23,882,000 | 2,087,000 | 190,000 | 549,000 | 26,708,000 | 11,659,000 | 15,049,000 |
| 1983 | 23,882,000 | 2,087,000 | 190,000 | 549,000 | 26,708,000 | 11,659,000 | 15,049,000 |
| 1984 | 23,882,000 | 2,087,000 | 190,000 | 549,000 | 26,708,000 | 11,659,000 | 15,049,000 |
| *Totals* | $518,357,000 | $35,393,000 | $5,226,000 | $11,919,000 | $570,895,000 | $249,058,000 | $321,837,000 |

* Ends Sep. 30.

† Income is based on population projection and water use as shown in a survey of Dallas County, Tex., prepared by the Bureau of Business Research, University of Texas, Austin, Tex., December 1954. These figures are considered to be ultraconservative, as they are based on minimum water sales. It should be noted that the projected net income does not reach the actual net income for the past fiscal year, ended Sep. 30, 1955, until the fiscal year ending Sep. 30, 1959.

for each community in the county. Estimates now indicate that the facilities will be required as early as 1962. This indicates that a new or additional investment in the water system of nearly $50,000,000 is required before supply will be fully available to the southeast portion of the city. This problem has two facets then: the ques- which cannot be forecast with any accuracy. The estimates up to 1980, however, are based on rather carefully estimated population and consumption figures. The net income available for capital looks imposing and, if the rate of growth is not too rapid, there is confidence that at least a large portion of the future planning can be accom-

plished within the present schedule of rates. This forecast, though, again brings out the effect of summer demand on the future operating expenses and capital charges of the utility. It must be recognized that, in establishing rates, a point of diminishing returns can be reached. On the present rate schedule, water bills of $80–$100 for homes on large lots are not uncommon in the summer. Even the modest home on a 75–100-ft lot has a lawn sprinkling bill frequently reaching $21–$30 per month. The point at which the homeowner will decide he simply cannot afford a green lawn must be weighed carefully if a significant portion of income is derived from sprinkling. This is especially true in Dallas where there is a seasonal load almost entirely attributable to lawn sprinkling. Figure 4 illustrates the summer load compared with winter base consumption. Although installed air-conditioning tonnage is of monumental proportions in Dallas, practically all is of a conserved type. Studies indicate that the summer demand load by air conditioning is somewhere in the vicinity of 10 mgd maximum compared to a sprinkling load of about 100 mgd. The expense involved in distribution, thus, comes back to the question previously discussed of a demand factor which will compensate for the disproportionate investment in distribution and plant facilities required to meet the seasonal load. There is always the specter of a recession which will leave less money available for the luxury of a green lawn, and one would expect the yard sprinkler to be shut off before the television set.

## Summary

Careful and regular analysis of utility earnings and investment is, therefore, needed, in order to project the capital costs involved in meeting expected growth. Careful study is needed of the rate structures to see that they are set less by political expediency and more by a fair and equitable charge for service as rendered to each type of customer. Thinking must be in terms of class rates. A demand

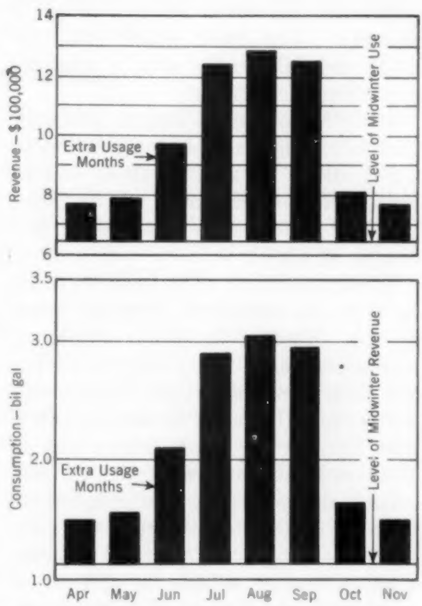


**Fig. 4. Domestic and Commercial Summer Consumption and Income and Average Winter Base**

*Data for billed consumption with industrial use were omitted.*

meter is needed for water service and it is necessary to start thinking, too, in terms of demand rates. City councils and the public need to be persuaded of the business nature of water works operations and the necessity for different classes of rates to meet the pattern of requirements for each. These things are true even though earnings may be adequate at this time.

## Los Angeles—*Burton S. Grant*

*A paper presented by Burton S. Grant, Asst. Gen. Mgr. & Chief Engr., Dept. of Water & Power, Los Angeles, Calif.*

At the turn of the century, the city of Los Angeles went into the water business by buying out the private water company. The population at the time was 102,449 in an area of 44.35 sq miles. The basic water rate was $0.15 per 100 cu ft, with a monthly minimum of a dollar.

In 1956, a special census indicated that Los Angeles had a population of 2,243,901 in an area of about 450 sq miles. The basic water rate is $0.16 per 100 cu ft plus a monthly service charge of $0.48.

These and many more statistics could be given to unfold the story of water in Los Angeles—a story which, in retrospect, reads like a fairy tale—but the limitations of subject matter will not permit. It should be said, however, that, but for the vision and energy of William Mulholland, who, with the surprising understanding and cooperation of civic leaders, constructed the 325-mile Los Angeles Aqueduct to bring a mean annual volume of 450 cfs of water from the mountains to the north and promoted the idea of bringing a mean annual volume of 1,500 cfs of water to Southern California from the Colorado River 300 miles to the east, Los Angeles today would be little more than the hamlet it was in 1900. Today, it is adding more population than any other city in the United States. In 10 years 576,000 population will be added—equivalent to a city the size of Minneapolis or New Orleans.

Everything but water rates has increased in fantastic proportions. But even so, a comparison of typical water bills in the sixteen largest cities in the United States ranks Los Angeles rates higher than ten and lower than five of these cities. In other words, Los Angeles water rates are higher than those of $\frac{5}{8}$ of these sixteen cities.

The electric system commenced operation in 1916. Los Angeles entered the electric business to distribute power which could be generated from falling water along the line of the Los Angeles Aqueduct. This system also has grown so that it now provides all electric energy used by the inhabitants and industry of the city. Energy is brought from Hoover Dam on the Colorado River, 300 miles to the east, and from the Owens River Gorge and other points along the Los Angeles Aqueduct from a distance 300 miles to the north. For a number of years, additional energy requirements have been met by the construction of steam generation plants located in and around the city. It is calculated that electric rates, today, are at least 40 per cent lower than they were in 1916. Today, this is the largest municipally owned utility in the United States.

### Utility Comparison

This article's chief concern is with financial aspects of water works management and its comparison with the finances of other types of public utility operations in an effort to solve some of the financial problems of water utilities. Comparison has been made with electric utility operation—a comparison which arose largely from two occurrences: First, at the 1956 St. Louis conference of AWWA John Murdoch pointed out the difficulties with which "75 Years of Too Cheap Water" (*1*) had confronted the industry and sec-

ond, the operating statements of the Danville, Va. Water, Gas and Electric Departments (2) were brought to the attention of the industry. Among other things, these statements show operating revenue to be $15.60 per water customer and $49.50 per electric customer. The question was then raised of why electric utilities are better revenue producers than water utilities.

John Murdoch has contributed heavily of his time and effort to the work of the Association. Although his above mentioned article is most worthy of the recognition for excellence it has attained, most papers of this kind have inherent limitations that compel some sacrifice of content. His "remedy" for too cheap water seems to be a result of this kind of sacrifice of content. Given ample time on the subject, it is doubtful that he would have resorted to a comparison of water and electric utilities. In effect, he says that water works management should sell confidence in its ability to provide adequate quantities of potable water at the lowest rates consistent with such service. This requires a plan and a set of objectives.

## Objectives

Most water works operators already know what must be done physically to provide adequate water service—but what of objectives? A few are:

1. Water works organization must not be subordinated to any other function of municipal government.

2. The department must be operated in a proprietary capacity, having control over its own funds, with the authority to effect a well planned financial program which would balance "pay as you go" with borrowed money. If it now relies upon appropriations from taxes, it must plan to be self-supporting through rates.

3. Fees should be collected from the municipality for all service provided, including public fire protection, at rates which, at a minimum, return all elements of cost.

These are examples of provisions under which the Los Angeles Department of Water and Power operates and without which the success of the department's operations would have been doubtful.

## Advertising

For over 50 years, efforts have been made to sell the public on the achievements of its water and electric systems in providing "a wealth of low cost water" and "plentiful power at extremely low cost." During the 1957 fiscal year $325,000 will be spent in institutional and promotional advertising. Each system will spend about $45,000 for institutional advertising, keeping resident owners informed of department activities. The power system will spend another $235,000 in promoting new load by cooperating with the national "Live Better Electrically" program and in rather intense programs promoting the use of electric ranges and dryers and inducing new industries to settle in Los Angeles.

The advertising matter proudly proclaims such slogans as "water costs only about 5 cents per ton," "239 gallons for a nickel," "3,800 glasses for a nickel," "plenty of water, and low in cost." Other advertisements state that "our electric rates are approximately a third less than the average of the fifteen other largest cities in the United States." Cheap? According to Webster, "cheap" means: "1. Bought or selling at, or charging, a low price or prices; inexpensive. 2. Costing little effort or trouble to obtain." Los Angeles water and electric energy are sold at low prices and are, thus, inexpensive

or cheap, but it would be a gross understatement to say that these commodities have been obtained with little effort or trouble.

For many years comparisons have been made of Los Angeles water works operations with that of other large cities, but with little worth-while result. Differences in source of supply, filtration needs, size and topography of area, density of population, relationship to the governmental function—all of these and more make comparison of little value. The value of comparison with electric operations, then, could hardly be expected to give the answers sought.

TABLE 7

*Operating Statistics of Los Angeles Water and Power Systems**

| Item | Water | Power |
|---|---|---|
| Operating revenue | $ 28,625,000.00 | $ 79,414,000.00 |
| Operating expenses | 14,485,000.00 (50.6%) | 50,435,000.00 (63.5%) |
| Depreciation | 5,668,000.00 (19.8%) | 11,977,000.00 (15.1%) |
| Taxes | 647,000.00 (2.3%) | 675,000.00 (0.9%) |
| Other income (net) | 360,000.00 (1.3%) | 1,504,000.00 (2.0%) |
| Net operating revenue | 8,185,000.00 (28.6%) | 17,830,000.00 (22.5%) |
| Net income | 5,831,000.00 (20.3%) | 12,891,000.00 (16.2%) |
| Operating revenue per customer | 54.74 | 95.79 |
| Operating revenue per capita | 12.76 | 35.39 |
| Net income per customer | 11.15 | 15.54 |
| Net income per capita | 2.60 | 5.74 |
| Utility plant (at cost) | 317,768,000.00 | 573,962,000.00 |
| per customer | 608.00 | 692.00 |
| per capita | 142.00 | 256.00 |
| per $1 operating revenue | 11.10 | 7.22 |
| per $1 net income | 54.49 | 44.52 |
| per $1 operating expense | 21.94 | 11.38 |
| Utility plant depreciated | 234,886,000.00 | 466,847,000.00 |
| Net income before interest and depreciation | 13,853,000.00 | 29,807,000.00 |
| Net income before interest and depreciation—percentage of utility plant depreciated | 5.9 | 6.4 |
| Net income—percentage of utility plant depreciated | 2.5 | 2.8 |

* The number of water customers is 522,900; power customers, 829,100. Population per customer is 4.3 for water and 2.7 for power.

Nevertheless, it may be shown by some comparison (Table 7) of the financial statements that when both water and electric systems are operated under the same policies and authorization, the end result is about the same.

## Policy

Some of these regulating policies as prescribed by the Los Angeles city charter state that the Department of Water and Power has the power and duty:

1. To construct, operate, maintain, extend, manage, and control works and property for the purpose of supplying the city and its inhabitants with water and electric energy
2. To regulate and control the use and sale of water and electric energy; to collect rates and to fix rates subject to city council approval by ordinance
3. To establish and maintain a system of retirement, disability, and death benefits
4. To pay out of its respective revenue funds all expenses of operation and maintenance; all debt service requirements; necessary expenses of constructing, extending, and improving the works, and of conducting and extending the business
5. To defray the expenses of a pension system
6. To create bonded indebtedness
7. To fix a salary or wage at least equal to that prevailing for the same quality of service rendered to private firms or corporations under similar employment.

## Expenditures and Financing

In 9 years, ending June 30, 1956, the water system spent $135,659,000 for capital additions, improvements, and replacements. Of this amount, 51 per cent was financed by the sale of $69,000,000 of revenue bonds with the balance coming from current earnings and working capital. Similar figures for the power system were for capital additions, improvements, and replacements, amounting to $372,206,000. Bond sales totaled $191,000,000, or 51 per cent, with the balance from current earnings and working capital.

The more important restriction applying to the sale of revenue bonds, either water or power, is that bonds outstanding may not exceed 1.25 times the respective earned surplus. In addition to this, covenant is made with bond holders that additional indebtedness will not be incurred unless the net income before interest, amortization, and depreciation of the works to which the debt applies, in the last prior fiscal year, is at least twice the amount of interest to accrue and at least 1.25 times the interest to accrue and payments of principal required in the fiscal year which is subsequently ending and in which such amounts will be the greatest on all indebtedness outstanding immediately after the issuance of any bonds. At the present time, the departments are well within all of these limitations, although trends indicate the need for some upward adjustment in rates to offset increases in operating costs and to carry increasing debt service charges.

## Influence on Revenue

But to return to the question: Why are electric utilities better revenue producers than are water utilities? Examination of some of the background of the two commodities is necessary. Since the beginning of time, water has been a necessity of life. With the development of the water utility, water was quickly put to additional uses—uses which have long since come to be considered standard to a normal way of life. Today, increased use of water relates more to increased population

than to new uses. On the other hand, there are many who can remember when mother reluctantly retired the kerosene lamp to the pantry shelf for ready access against the time when her new 16-candlepower carbon lamp, which dangled from the ceiling, should fail to function. New uses of electricity have grown, in a generation, from the unreliable carbon lamp to commonplace use of the electric light, radio, refrigerator, iron, clock, washer, television, and any number of other devices in homes today, to say nothing of those found in business and industry. In fact, electricity is now so interwoven with the fabric of everyday living that it is given no conscious thought—and yet, its use has only just begun. Oddly enough, it seems as if modern expansion of water use is largely dependent upon electricity, as in the automatic dish washer, the garbage disposal unit, and air conditioning. Although today's electric bill is at least double the water bill, in another 50 years it will be several times that, because new uses for electricity will grow disproportionately to new uses for water.

## Conclusions

Comparison of water revenue per customer with electric revenue would be as appropriate as comparison of water revenue with the customer's requirements for other necessities of life such as food, clothing, housing, or medical care. All of these take a much larger part of the family budget. Should such a difference be an indication that water is being sold too cheaply? This is no more likely a conclusion than that electricity should be sold for no more per customer than water.

## References

1. Murdoch, John H. Jr. 75 Years of Too Cheap Water. *Jour. AWWA,* **48**:925 (Aug. 1956).
2. Report of Operations, First Six Months 1956. Water, Gas, and Electric Depts., Danville, Va. (1956).

# Danville, Va.—*Edgar M. Hawkins Jr.*

*A paper presented by Edgar M. Hawkins Jr., Vice-Pres., Michigan Gas Utilities, Coldwater, Mich., formerly Mgr., Water, Gas & Electric Dept., Danville, Va.*

A discussion of whether water utility earnings are adequate should lead first to the questions: "How have earnings been determined? Does the water utility under question follow an accepted accounting system in the listing of revenue, the allocation of expenses, and the recording of capital improvements?

The industry is composed of many sizes and types of units, all supplying an essential service, whether the number of customers be a hundred or several million. The smaller units outnumber the larger utilities. Municipally owned plants represent approximately 80 per cent of the total. Because of these differences and lack of standard reporting methods, a comparison of earnings and operating results among water utilities is not always meaningful.

## Uniform Accounting System

If an accurate determination of the adequacy of earnings for an individual water utility is to be made, it must be established that a proper accounting system has been followed and that the

figure at the bottom of the page of the income statement reflects a true result in accordance with the best accepted practice of the industry.

The industry needs a uniform system of accounting. This would be a big help in discovery of the cause of inadequate earnings in a particular property; when the true condition becomes known, corrective action often follows.

No statistics are available covering the industry as a whole, such as those reported in the gas and electric fields by the American Gas Association, the Edison Electrical Institute, and the Federal Power Commission. A compilation of reports issued by a selected group of water companies, however, appears sufficiently broad to provide a rough guide to recent industry trends. Data to illustrate observations in this article have been drawn from these sources and from statistics gathered by the Danville, Va. water department with which the author was associated from 1946 to 1956.

## Revenue and Investment

The first question under discussion is: What is the relation of revenues to investment—not only in the water utility, but in gas and electric utilities—and what is the significance of this relationship?

The water utility is characterized by a very large investment in plant per dollar of gross revenue. According to the AWWA, the water industry in 1950 represented a capital investment of almost six billion dollars with the value of its product about $750,000,000 annually. In other words, there is an investment for $8 for every dollar of gross revenue. An analysis of the 1955 AWWA survey of water works operating data (*1*) indicates that the net plant investment per dollar of gross revenue has increased to approximately $8.50. Comparable figures on an industry-wide basis are $3.26 for electric operations and $1.60 for gas. In Danville, these statistics are $7.50 of net plant investment in water facilities for every dollar of gross revenue. The electric department required approximately half that amount—$3.50—and the gas investment constituted about $\frac{1}{6}$ that of the water per dollar of revenue—$1.20. These are in line with the industry figures.

There is a vital significance in this fact of large investment per dollar of revenue in a water utility. The wages that the investment should earn, whether interest charges or dividends, are a major item in the income statement. Depreciation and property taxes are also based on plant investment and, therefore, these items represent a larger percentage of gross revenue in the water utility than do similar items in the gas and electric operations.

The three items—return on investment, depreciation, and property taxes—take $0.42 from every revenue dollar in the Danville water utility. For electric and gas, the comparable figures are $0.30 and $0.11.

These costs, which are largely controlled by the investment in plant, are elements just as real in the cost of service as payroll, chemicals, pumping costs, and supplies. Earnings, to be adequate, must cover all these items and accounting records and procedures should permit accurate determination of these facts.

## Growth and Revenue

The second major question is: What does growth have to do with adequacy of water revenues?

The past decade has been a period of unprecedented construction of new housing. Water utilities have faced the problems of enlarging and extending

their facilities to meet the demands made on them. This has been a period of substantial growth—physically as well as in dollar value. It is a familiar fact that construction costs have trended upward. The index of cast-iron main construction is a good criterion of the trend. Using the cost level in 1940 as equivalent to 100, that index stood at 265 at the end of 1956. In other words, it was more than 2.5 times more costly to install those facilities last year than it was 16 years ago.

In comparison, the same authority quotes the index for construction costs of electric distribution plant as 235 at the end of 1956 with a 1940 base of 100. Apparently, the electric utilities have not experienced quite as large a price rise in construction costs as the water industry.

The utility operating income expressed as a percentage of net plant, is a rough guide to the rate of return on the investment and also is a measure of the adequacy of earnings. The best figures available showed that in 1955, twelve major water companies with total customers of over 1,600,000 had a rate of return of 4.8 per cent. Ten years ago it was 5.45 per cent. This indicates that rate increases have not kept pace with rising costs nor have they give full consideration on an industry-wide basis to the cost of new construction under present inflationary conditions.

The relative stability of earnings in a water utility results from the character of the product and the large number of customers served. These are possible reasons why water utilities have been able to get by with only moderate fluctuations in bond interest coverage, but they do not justify continuance of the low rate of return.

Compared with this present rate of return of 4.8 per cent for these major water companies, the rates for the electric and gas industry are 5.9 per cent and 6.6 per cent, respectively.

Funds must be raised to pay for additional plant investment. This can be accomplished at the most favorable rates when earnings have been adequate to cover the costs heretofore listed and sufficient to provide a reasonable surplus. The equity ratio must remain at a figure that attracts funds for plant expansion at reasonable rates. For a privately owned utility this is of great importance. Its ability to borrow money at prime rates is a measure of its standing in the financial community. For the publicly owned utility the same is largely true, although the general credit of the municipality often serves as a guarantee of the water bonds.

## Rate Comparisons

The third and final question bears on the fact that consumers are paying an annual bill for other utilities of several times the amount of the water charges. Must water revenues remain low in comparison?

To answer this, specific figures from Danville, Va. are used rather than industry-wide statistics. The results, however, would be similar.

The average residential customer in Danville pays $20 per year for his domestic water requirements, $64 for electricity, and $92 for gas. In evaluating this comparison, it is of interest to note the trend in use per residential customer. The use of water in the home has increased only 10 per cent in the past decade. The installation of dishwashers, home laundries, and other water consuming equipment does not appear to have greatly affected use by the average residential customer. Because of an increase in rates, the water bill is 20 per cent higher than it was 10 years ago.

In contrast to the water user, the average residential electric customer uses three times the electricity he used in 1946. During the last decade there has been a shift from manufactured to natural gas, with the result that gas has become the desired fuel for house heating. The use per residential customer has multiplied more than fivefold. It appears that gas and electricity are responsive to promotional efforts while the use of water remains rather static on a per capita basis.

Too often, the emphasis has been placed upon the cheapness of public water service. The customer has been told that a few pennies is all that it costs to have a ton of water delivered to his home. Seldom has the public been educated to the true value of a dependable water supply of unquestioned purity. The water utility, if it is suffering from inadequate earnings, is largely itself responsible for the situation. The AWWA must assume leadership in influencing consumer thinking with reference to the true value of water. When that is done there need be no fear as to the outcome of a program for adjustment of water rates to provide adequate earnings.

### Reference

1. STAFF REPORT. A Survey of Operating Data for Water Works in 1955. *Jour. AWWA*, **49**:555 (May 1957).

## Adequacy of Earnings—*M. H. McGuire and Fred Merryfield*

*A paper presented by M. H. McGuire, Mgr., McMinnville Water & Light Dept., McMinnville, Ore., and Fred Merryfield, Prof. of San. Eng., Oregon State College, Corvallis, Ore.*

If one were to pose the question: Are water utility earnings adequate? the answers would vary from city to city and from private utility to private utility. This is particularly true in smaller cities or operations where a council or a board of directors has the ultimate management of the utility. Councils tend to develop rates based on how much can be collected for the general fund with as little expenditure as possible for the operation of the utility. Rates in some cities are a reflection of the average rates of the surrounding water utilities.

### Responsibility

The responsibility for developing better and more real rate structures depends on the superintendent who should advise the board or council on all matters, including costs of operation. This is even more true in utilities where expansion is contemplated. The superintendent should stress the need for earning reserves adequate not only for extension and expansion but also for investigation and planning of these additions.

The superintendent who is too busy with the daily task and the political councilman with little or no experience are those responsible for keeping water too cheap. Pressure from local booster organizations also has a tendency to exert pressure, in turn, on the council to maintain low rates in the hope of attracting customers who use large volumes of water. The public needs to be informed, but the superintendent should first have an intelligent grasp of plans and operations in order to in-

TABLE 8

*Costs in Percentages of Total Operating Revenues, Knoxville Utilities Board*

| Item | 1947 | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955* | 1956 | 1957† |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Electric Division | | | | | | | | | | | |
| Total Operating Revenues | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Total Operating Expenses | 59.96 | 60.65 | 58.97 | 59.79 | 60.91 | 64.76 | 63.77 | 65.24 | 63.11 | 63.86 | 65.13 |
| Depreciation | 6.92 | 7.11 | 7.75 | 7.86 | 8.74 | 9.22 | 9.52 | 9.43 | 9.78 | 10.22 | 10.03 |
| Tax Equivalent | 5.74 | 5.36 | 5.53 | 5.52 | 5.71 | 5.82 | 6.30 | 6.27 | 6.30 | 6.26 | 5.94 |
| Total Operating Deductions | 72.62 | 73.12 | 72.25 | 73.17 | 75.36 | 79.80 | 79.59 | 80.94 | 79.19 | 80.34 | 81.10 |
| Gross Income | 27.75 | 27.12 | 28.11 | 27.01 | 24.87 | 20.38 | 20.56 | 19.16 | 20.89 | 19.86 | 19.10 |
| Total Income Deductions | 3.58 | 2.94 | 3.32 | 2.82 | 2.89 | 2.57 | 2.33 | 2.08 | 2.00 | 2.12 | 2.47 |
| Net Income | 24.17 | 24.18 | 24.79 | 24.19 | 21.98 | 17.81 | 18.23 | 17.08 | 18.89 | 17.74 | 16.63 |
| Water Division | | | | | | | | | | | |
| Total Operating Revenues | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Total Operating Expenses | 50.23 | 52.53 | 53.95 | 53.80 | 55.61 | 55.93 | 64.93 | 66.83 | 61.27 | 59.22 | 63.87 |
| Depreciation | 9.04 | 8.86 | 9.27 | 9.22 | 8.90 | 8.64 | 8.92 | 9.30 | 8.41 | 8.66 | 9.25 |
| Tax Equivalent | 11.88 | 11.21 | 11.37 | 11.02 | 10.29 | 9.61 | 7.03 | 6.36 | 5.76 | 5.60 | 5.74 |
| Total Operating Deductions | 71.15 | 72.60 | 74.59 | 74.04 | 74.80 | 74.18 | 80.88 | 82.49 | 75.44 | 73.48 | 78.86 |
| Gross Income | 30.03 | 28.86 | 26.48 | 26.05 | 25.39 | 26.01 | 19.28 | 17.82 | 24.79 | 26.60 | 21.22 |
| Total Income Deductions | 10.93 | 9.68 | 8.20 | 6.43 | 5.60 | 5.42 | 4.96 | 5.39 | 4.76 | 4.37 | 4.03 |
| Net Income | 19.10 | 19.18 | 18.28 | 19.62 | 19.79 | 20.59 | 14.32 | 12.43 | 20.03 | 22.23 | 17.19 |
| Gas Division | | | | | | | | | | | |
| Total Operating Revenues | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Total Operating Expenses | 86.99 | 84.82 | 71.85 | 74.02 | 64.73 | 72.63 | 78.42 | 69.34 | 73.49 | 74.18 | 76.09 |
| Depreciation | 6.81 | 5.85 | 5.91 | 6.01 | 5.60 | 5.36 | 4.63 | 4.44 | 4.11 | 4.05 | 4.10 |
| Tax Equivalents | 3.81 | 3.11 | 1.60 | 1.71 | 2.00 | 2.10 | 2.53 | 2.28 | 2.29 | 2.55 | 2.53 |
| Total Operating Deductions | 97.61 | 93.78 | 79.36 | 81.74 | 72.33 | 80.09 | 85.58 | 76.06 | 79.89 | 80.78 | 82.72 |
| Gross Income | 2.39 | 6.22 | 20.64 | 18.37 | 27.77 | 19.99 | 14.42 | 24.12 | 20.22 | 19.36 | 17.46 |
| Total Income Deductions | 1.91 | 16.60 | 1.48 | 1.44 | 1.46 | 1.91 | 1.53 | 1.18 | .96 | .83 | .65 |
| Net Income | .48 | 4.62 | 19.16 | 16.93 | 26.31 | 18.08 | 12.89 | 22.94 | 19.26 | 18.53 | 16.81 |

* Increase in water rates effective April of this year. † Estimated.

form the council and then the customer. Consultation advice and planning should be sought by the superintendent.

### Earnings Data

The cost of water plant additions in McMinville for the last 10 years totaled $1,105,000. There has been no rate increase—only an adjustment. The gross yearly revenue has increased 52 per cent. Net earnings have increased $588,000, which includes a net profit of $233,000 on timber sales from the watershed. The net earnings from water sales, then, have been $355,000 for the 10 years, 1946–1956. New customers within the city are governed by the rules of installations of services. Customers outside the city should pay more for water than city customers because security and responsibility for bonded debt is a lien on city property. In addition, the cost of service is higher.

### Policy

Water inside the city should not be served at cost. No business—and a water utility is a business—can exist long as a strong service group without following the pattern of normal good business procedures and common sense. Water should not be singled out as the "country cousin." The concept held by many, that, because electrical demands are increasing there is need for a better return on the dollar is incorrect. Although there has not been a phenomenal increase in the per capita consumption of water similar to the increased electrical demand, there has been an increase in per capita per acre increase in the urban section. Other factors, too, such as polluted sources, drought, and storage, as well as materials, equipment and supplies, maintenance, power, and reasonable wages are pertinent in the economical development of all water utilities.

One thing that has not been conveyed to the consumer is that water today is a different commodity from that which was served to grandfather. Some of grandfather's friends died from using it, and the well did run dry. Other utilities inform the customer of their value and importance; the water utility should do the same.

## Knoxville—*Mark B. Whitaker*

*A paper presented by Mark B. Whitaker, Gen. Mgr., Knoxville Utilities Board, Knoxville, Tenn.*

Most water utility operators firmly believe that a water utility must always be a marginal financial operation. This thinking, of course, is the result of the historic precept, common among water works people, that water is essential to life and must be sold to the consumer at practically the cost of purification and distribution.

### Knoxville Utilities Board

There are exceptions to this line of thinking, particularly among people charged with the operation of more than one utility under one governing body. The Knoxville Utilities Board of Commissioners is an autonomous body charged with the responsibility of serving the community and adjacent areas with gas, water, and electric power. The board's basic policy may be expressed in these few words: To provide adequate gas, electric, and water service to the utilities customers in an efficient and business-like manner. This policy is all inclusive, and applies

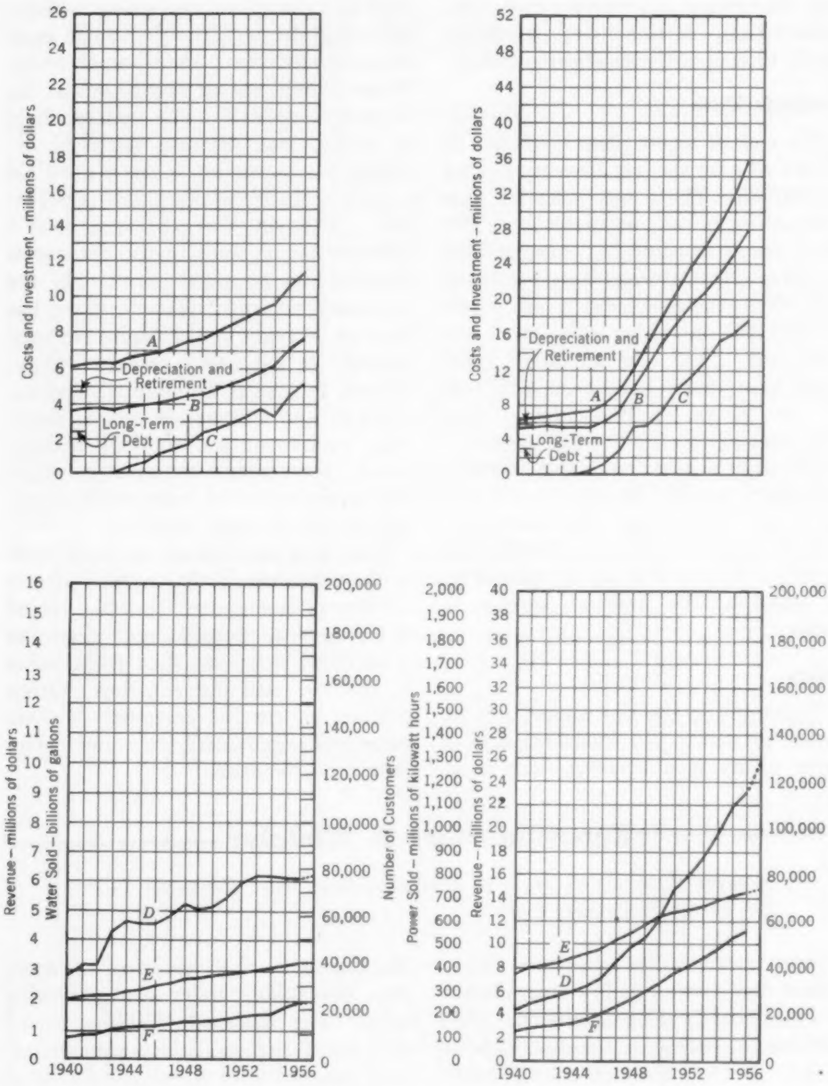


**Fig. 5a. Cost, Revenue, and Consumer Data, Knoxville**

*Left-hand diagrams are for the water division, those at the right for the power division. In both divisions, Curve* A *represents total utility plant; Curve* B, *net utility plant;* C, *Knoxville Utilities Board equity. Curve* D *indicates amount of commodity sold; Curve* E, *number of customers; and,* F, *total revenue.*

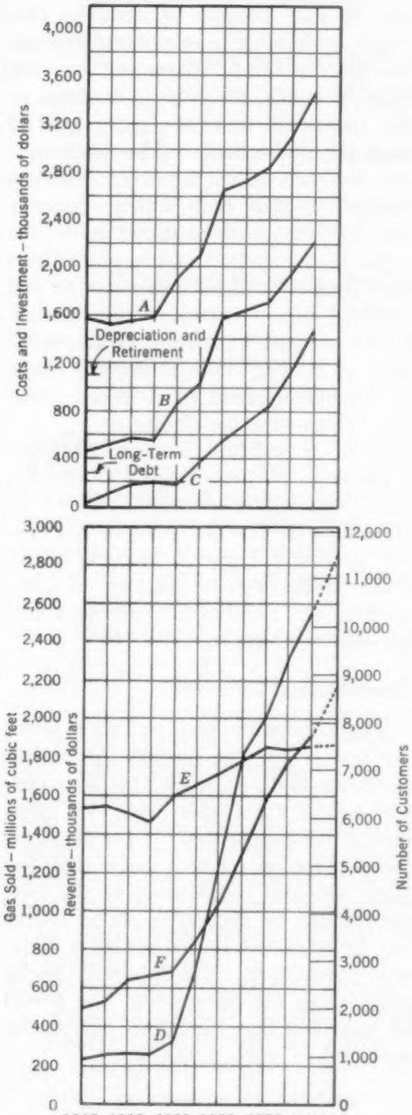


**Fig. 5b. Data for Gas Division**

*Curve* A, *total utility plant;* B, *net utility plant;* C, *Knoxville Utilities Board equity;* D, *amount of commodity sold;* E, *number of customers; and* F, *total revenue.*

to the expansion of all systems on a sound financial basis—the water system included.

This system is treated the same as the gas or electric systems. It is managed as a utility that has to pay its own way. The operating revenue dollar, operating expense, tax equivalent, amortization of bonded indebtedness, and earned surplus are all given careful scrutiny and consideration and adjusted in accordance with sound business principles. There are, of course, some seasonal characteristics in the use of gas, water, and electricity that must be considered in operation of the distribution systems and in anticipating the growth of the systems.

TABLE 9

*Comparison of Cost of Capital Additions for the Three Utility Divisions, Knoxville**

| Year | Water | Gas | Electric |
|---|---|---|---|
| 1947 | 17.7 | 9.8 | 23.9 |
| 1948 | 18.8 | 7.6 | 46.6 |
| 1949 | 7.4 | — | 46.5 |
| 1950 | 25.0 | 45.4 | 40.2 |
| 1951 | 24.5 | 19.2 | 28.8 |
| 1952 | 19.8 | 50.9 | 27.2 |
| 1953 | 25.4 | 5.5 | 15.7 |
| 1954 | 4.5 | 5.1 | 19.1 |
| 1955† | 74.7 | 12.6 | 21.8 |
| 1956 | 31.4 | 14.5 | 26.9 |
| *Avg.* | 26.6 | 15.9 | 28.0 |

* All figures percentages of revenue dollars. Capita secured from depreciation reserve, net income, and sale of bonds.
† Water rates increased in April.

## System Comparisons

There are few ways to increase the use of water, as its basic use is the same as that of many generations ago (with air conditioning an exception). On the other hand, there are now at least 130 different uses of electric power compared to 40 different uses about 10 years ago. Since natural gas has be-

come available in practically all parts of the country, its use has rapidly grown in public favor. These factors, to some extent, are reflected in the growth of the systems. Of the three, the water system is usually the one that expands most slowly. The relative financial picture of three systems under one management is given in Table 8. The accounting for the three systems is similar, in that the uniform system of accounts is used. Table 8 indicates that for 1956 the water system has available a greater percentage of its revenue dollar for bond retirement or construction than either the gas or electric systems. It also shows, by years, the major items of the financial affairs of the systems for the past 10 years. The net income of each system, in percentage, varies from year to year because of variables that affect each system—economic factors, changes in rates, retirement or new issue of bonds, or such other items as the increased cost of labor, cost of material, and others. The basic pattern for each utility, however, does not change, in that each utility shows a net income commensurate with the needs of the system and in accordance with the policy of adequate service and business-like financial administration. Under present expansion of the economy, of course, there is nothing static in the management of a utility; each day brings new problems.

TABLE 10

*Increase in Total Operating Costs and Revenue, for Water Division 1947–56**

| Year | Costs | Gross Revenue |
|---|---|---|
| 1947 | $ 97.51 | $194.12 |
| 1948 | 101.57 | 193.36 |
| 1949 | 110.88 | 205.53 |
| 1950 | 110.31 | 205.02 |
| 1951 | 111.79 | 201.02 |
| 1952 | 111.59 | 199.50 |
| 1953 | 129.56 | 199.53 |
| 1954 | 136.97 | 204.97 |
| 1955† | 142.92 | 233.26 |
| 1956 | 156.59 | 264.41 |

* All figures per million gallons.
† Rate increase in April.

Table 9 indicates capital additions expressed in percentage of revenue dollar and source of capital. Table 10 gives data on cost and revenue per million gallons. Figure 5 consists of six charts indicating the amount of commodity sold, number of customers, and revenue received.

## Conclusions

The comments and statistics given are simply for the purpose of raising questions and indicating that it is possible to operate a water utility on other than a marginal basis. If the cooperation of the governing body and the good will and cooperation of the customers can be secured a water utility can be operated under ordinary business procedures. Not only will this be accepted in the community, but it will be expected that the utility should be operated in such a fashion.

# Development of a Rural Public Water Supply

## *Joint Discussion*

*A joint discussion presented on Mar. 19, 1957, at the Southeastern Section Meeting, Charleston, S.C.*

## Limited Service to Partially Developed Areas—*J. Moran Roberts*

*A paper presented by J. Moran Roberts, Asst. Mgr., Munic. Dept., Roberts & Co., Assocs., Atlanta, Ga.*

MANY factors are involved in developing water systems in county or rural areas to provide limited domestic water service near urban developments that are only partially developed and require limited water service only. The factors may sometimes depart from general or accepted engineering practices and will require careful economic considerations to determine the feasibility of providing service even in its meager form. In an article of this kind numerous assumptions have to be made, assumptions which should not be confused with an actual survey since it is essential that a complete analysis always be made of each area and each part of an area to determine what can be developed and the best approach.

Quite often areas demand service as a result of inability to obtain water elsewhere, so that they are willing to pay considerably higher than usual rates. The cost of distributing water is a serious drawback in the creation of a system. This fact is contrasted with electrical distribution where adequate service at moderate voltages can be furnished to customers through a No. 0 copper wire that weighs 0.32 lb per foot. An 8-in. pipe which is the normal size required for distribution of water at moderate pressures weighs 37 lb per foot, more than 100 times as much.

Among important factors in the development of a rural water system are the attitudes of the server and the people to be served. People must have a desire to be served, and the utility must approach the analysis and the negotiations with a liberal attitude. It is almost impossible to serve a county with the same high standards applied to urban areas, but if both parties are willing to cooperate, the system has a better opportunity of succeeding. The utility should expect to do no more than break even in the early years, and to wait for future growth before showing a profit.

A casual review of a map will often determine the potentialities of the area. Aerial photos or highway planning maps can be used to count the number of houses along a road and areas that are not sufficiently populated can be eliminated. A house count may sometimes be necessary in order to determine the number of potential customers. Residents are classified into three groups: [1] definite customers; [2]

probable customers; [3] definitely not customers.

These classifications may be made by observation of the house and surroundings without an interview with the occupant. After making the classifications, customers are estimated by counting all the definites, half of the probables, and none of the indefinites. Filling stations should be evaluated on the basis of their probable usage—superior stations classified as two customers, and normal or small stations classified as only one.

The first consideration of any water system is a source of supply. In establishing a rural county system, the source is usually a stream, wells, or the existing facilities of a nearby city system.

## System Design

It is usually necessary that the rural county system be designed on a minimum basis. The pipe diameter should remain as small as possible, and construction cost should be held to a minimum. Fire protection normally cannot be considered as the pipe diameters required would be entirely too large for economical construction.

A normal water system is designed to have large-diameter feeders, with branching laterals of smaller diameter. In the design of a system serving a sparsely populated area the reverse is customary. The small laterals are first laid and the service connections are made from them under the assumption that large feeder mains will be constructed later when the area develops further. Most customers will be living along the present highways, and few, if any, on the back roads. When the land between the highways is developed, new roads are put in, and feeders can be laid to follow the new roads, thus also providing service to the new areas. Careful consideration should be given to the areas of future development in order to size mains adequately.

Hydrants and valves may be placed at greater distances than normal; hydrants will only be used as "blow-offs," and additional valves may be placed later when supporting cut-ins are made.

Notation of elevations in the area are necessary in order to determine if booster stations or elevated storage will be required in the initial development. These can usually be obtained from US Coast and Geodetic Survey quad sheets or, if these are not available, accurately adjusted barometers will be suitable for determining preliminary elevations.

The costs involved in developing a water system in a sparsely inhabited area can differ radically according to the type installed. Three case histories will be given to illustrate this point. In all three examples, the following constants will apply: [1] the system contains 1,000 connections; [2] the monthly usage is 4,500 gal per connection; and [3] the gross income to the utility will be $1 per 1,000 gal, or $4.50 per month.

## Urban Extension

The first example deals with the extension of an existing system into a rural area. The system is owned and operated by a centrally located city utility.

In order to determine the unit cost of maintaining and operating the new system, three estimates must first be made:

1. An estimate of the fixed operating costs, such as billing, collecting, maintaining and operating the system, and

other overhead items must be made by a thorough audit of the existing system.

2. An estimate of the cost of producing and distributing water is made by determining power, chemical, labor and other costs.

3. An estimate of the average consumption of existing consumers should be made by studying meter records. Consideration should also be given to any special uses of water such as stock watering and irrigation.

Using these estimates, operating costs are calculated as shown in Table 1.

TABLE 1

*Estimated Operating Costs Per Customer*

| Item | Cost Per Connection Per Month—$ |
|---|---|
| System maintenance and other overheads | 1.05 |
| Cost of water* | 0.45 |
| *Total* | 1.50 |

* Estimated at 10 cents per 1,000 gal, with a consumption rate of 4,500 gal per month.

The next step is to determine the unit capital or debt service cost to be applied. Many water systems are financed by revenue bonds. The bondholders are assured a dividend on their investment as are holders of corporation stock. The utility operator is thus responsible for meeting sinking fund payments so that the principal and interest payments may be made.

When an existing utility is extending into the surrounding area, the coverage or margin between revenue available for debt service and debt service requirements does not have to be as wide as in a system relying entirely upon new construction. At $3\frac{1}{2}$ per cent interest, 30-year revenue certificates will require repayment at the rate of 5.44 per cent annually to meet principal and interest. If the existing utility is well financed, has a good rate, and is able to show at least 1.5:1.0 coverage on all customers (including the new ones), the annual payments need only be enough to show a reasonable profit and to provide its prorated part of the coverage. For purposes of these comparisons, a 6 per cent rate will be used.

The construction cost of lines to be extended must then be determined, remembering that the lines are considered as laterals, and not feeders. An advantage of this factor is that laying costs for such mains are usually lower, as they can normally be laid on highway shoulders with a minimum of backfill.

Cost of construction materials is rising every day. The average cost of cast-iron pipe today is approximately 50 cents per inch diameter per foot. The cost of 2-in. pipe is thus approximately $1.00 per foot; 6-in. pipe, $3; 8-in. pipe, $4; and 10-in. pipe, $5.

Booster stations should be kept as simple as possible by placing them just off the highway shoulders and using simple pumps, high speed motors, pressure switches, relief valves, time delay switches, and other controls that will eliminate the need for storage. When feeder mains are constructed later the booster stations will probably not be required and thus can be retired. Small booster stations of this nature will cost approximately $6,000 each.

Rates must then be set to meet the expected costs. It is general practice for municipalities to have a higher rate outside their city limits. In developing systems for thinly populated areas the

TABLE 2

*Estimated Net Income Per Customer*

| Item | Amount Per Month—$ |
|---|---|
| 4,500 gal water | 4.50 |
| Operating cost | 1.50 |
| Net for capital cost | 3.00* |

* $36.00 per year per customer estimate.

rate must necessarily be set as high as possible. For small customers averaging 4,500 gal per month, a single rate is applicable, such as $1 per 1,000 gal. The net income the utility can expect to receive per customer is shown in Table 2.

Construction costs to service the area can now be estimated. For 15,000 ft along a highway or road, the estimated costs are $56,000, as shown in Table 3. Capital requirements for this line would be 6 per cent of $56,000, or $3,360. Dividing the capital requirement by the capital cost per year per customer ($36), it is calculated that 94 connections are necessary. This amounts to one connection every 160 ft.

Each line radiating from the city can be analyzed in the same manner; it will be found that there are differences in connection spacing. These requirements can be the average of several lines, so that the more profitable one will help finance those not so well developed.

TABLE 3

*Estimated Construction Costs for 15,000 ft Along Highway*

| Item | Unit Cost $ | Total $ |
|---|---|---|
| 5,000 ft of 8-in. pipe | 4 | 20,000 |
| 10,000 ft of 6-in. pipe | 3 | 30,000 |
| Booster station | 6,000 | 6,000 |
| *Total* | | 56,000 |

Future customers should be taken into account as availability of water will usually attract further development. If revenue-bond financing is being used, little value can be placed on future development. No great hazard is involved, however, in allowing for slightly more than the existing number of customers, as future development will make the lines after construction more profitable than the initial analysis indicated.

## Independent System

In the second example, a new system is owned and operated independently, having its supply imported from an adjacent system. Master meters tabulate the amount of water imported for redistribution.

Calculation of net revenue before debt service will have to be based on estimates as no previous records will be available for the new system. For purposes of comparison, overheads will be estimated as the same as in the first example, although they are likely to be higher as a result of a smaller and relatively inexperienced operational knowledge.

Rates for the water purchased through a master meter at the city limits or some other agreed boundary, will provide for a return on the investment of the seller. If the cost of water is 10 cents per 1,000 gal, the supplier will probably charge not less than twice that amount to meet his return on his investment and maintenance costs. The expected cost per new customer will be $1.95, as shown in Table 4.

Capital costs are determined as in the first example. It will be necessary,

however, that full 1.5:1.0 coverage be developed as the new system cannot take advantage of the old customers in the thickly populated area. On a new venture of this type the interest rate will, in all probability, be higher than it would be for additional certificates to an established system. To keep to a simple comparison of the two examples, however, the interest rates obtainable will be assumed to be the same. The percentage of capital costs required will thus be: 5.44 per cent for equal annual payments to retire principal and interest. The amount of capital costs will thus be: 5.44 per cent of the total costs for equal annual payments to retire principal and interest; and 2.72 per cent to provide 1.5:1.0 coverage. The capital costs requirements will thus be 8.16 per cent.

TABLE 4

*Estimated Operating Costs Per Customer*

| Item | Cost Per Customer Per Month $ |
|---|---|
| System maintenance and other overheads | 1.05 |
| Cost of water* | 0.90 |
| *Total* | 1.95 |

* Estimated at 20 cents per 1,000 gal, with a consumption of 4,500 gpm.

Construction costs will remain the same as in the first example (50 cents per diameter inch per foot of cast-iron pipe). The income per customer will also remain the same ($36).

The costs involved in the construction of a line can now be estimated. With 15,000 ft of line and one booster station, the cost breakdown will be the same as that shown in Table 3 (total $56,000), with one addition—$2,000 for a master meter, bringing the total to $58,000. The capital cost requirements will thus be 8.16 per cent of $58,000, or $4,730. This sum, divided by $36 expected net income per customer, makes it necessary to have 132 connections, or approximately one connection every 114 ft.

Two factors have made it necessary to have more connections than in the previous example: [1] the additional cost of the water imported into the system; and [2] the additional coverage necessary to finance the venture.

## New System

The last example, which is concerned with the development of a new system and a new source of supply, is hypothetical. The estimates are not intended to be accurate, but are merely given in order to outline the approach to the analysis.

TABLE 5

*Estimated Capital Cost for New System*

| Item | Amount $ |
|---|---|
| One 1-mgd filter plant and raw water pumping station | 200,000 |
| Feeder mains | 175,000 |
| Laterals | 600,000 |
| Storage facility | 45,000 |
| *Subtotal* | 1,025,000 |
| Contingencies | 102,000 |
| *Total* | 1,127,000 |

This system will require a 1-mgd plant, and it is assumed that a stream or other source of supply will be conveniently located to serve the area. A breakdown of the capital cost would probably be something like the one shown in Table 5.

The operating cost will necessarily be somewhat greater than was estimated for the other system, as more supervision will be required for source of supply expense, feeder main maintenance, and other items that were not involved before. The annual overhead operating cost for this system would be about $20,000 on the basis of 1,000 customers at $20 each.

The cost of producing water would be estimated as being the same as in the first example—10 cents per 1,000 gal. On this basis the annual cost of producing water for 1,000 customers would be:

$$1{,}000 \times 4{,}500 \times 12 \times 0.10 = 5{,}400$$

to which must be added $20,000 operation costs to bring the cost to $25,400.

The debt service might be considered to be the same as in the second example, in which a 1.5:1.0 coverage and equal annual payments for principal and interest were provided. The overall debt service requirement of the principal would again be 8.16 per cent. Applying this to the capital costs would result in a total debt service of $92,000 per year.

The debt service plus the operating cost would require that the annual gross income be $117,400. Assuming 1,000 customers each would have to yield $117.40 per year, or $9.83 a month. If the usage were 4,500 gal per month, the water rate would have to be $2.18 per 1,000 gal.

It is certainly not intended to convey that a new water system would never be profitable. It is quite likely that 1,000 customers could be served with considerably less capital cost than is here assumed. Where the customers were concentrated, the cost of the feeder mains and the distribution system could be greatly reduced. It will be noted that the cost of water is over twice that in the previous examples—certainly partly a result of the fact that the capital cost represents approximately 78 per cent of the total cost.

## Conclusions

The value of the previous examples should lie in their simplicity, clarity, and convincing evidence that every line or area should be analyzed and studied thoroughly before any construction is undertaken or certificate offered for sale. It happens that the first example follows closely the results obtained when the area adjacent to Gainesville, Ga., was studied. The second example was based principally on a preliminary study made for a municipality. The study was not continued as it could be determined from the information at hand that the system would not be profitable without additional financing or subsidy.

In the last of the examples given, if 68 per cent of capital cost were to be subsidized, or if general obligation bond funds were to provide $760,000 of the $1,127,000 required, the development of the new system would become feasible with a water rate comparable to the other two examples.

County water systems are becoming more and more popular, and they are often both mechanically and financially feasible. Many such systems will undoubtedly be constructed in the future to keep pace with the American high standards of living.

## Gainesville, Ga., Experience—*T. Riley Milam*

*A paper presented by T. Riley Milam, City Mgr., Gainesville, Ga.*

Many cities today are suffering growing pains. Communities which have developed outside city limits will often be quite reluctant to be incorporated into the city, yet water must still be supplied to them. Some city officials feel that to extend the city distribution system to these areas only encourages them in their obstinacy. Other officials feel that to supply unincorporated areas with water creates in them a desire for other city services, which can, of course, be supplied only with incorporation.

In Gainesville, Ga., water lines running outside city limits have been on a paying basis for some time. Customers in these areas are neither anxious nor skeptical in their dealings with city officials, for they know through experience that the city can be trusted.

Gainesville receives its water supply from Lake Lanier, an artificial lake which was created by the damming of the Chattahoochee River, at Buford Dam. In 1953, when it became certain that the dam would become a reality, the Gainesville city fathers were obliged to take immediate steps to build a new filter plant, as the old one was in an area which was to be flooded.

### Financing

It was decided to finance the new construction by issuing revenue certificates. Certificates to the amount of $550,000 had already been issued in the past. As of Jan. 1, 1953, an additional $450,000 in certificates was issued. In the same year, the city received $300,000 from the US government, which had built the new dam, in consideration for the flooded plant. More revenue certificates were issued to keep pace with building: on Oct. 1, 1954, $250,000; on Jul. 1, 1955, $400,000; on Jan. 1956, $500,000; on Jun. 1, 1956, $500,000; and on Mar. 1, 1957, $500,000. As of Dec. 31, 1956, the total amount of revenue certificates outstanding was in the amount of $3,008,000.

### Signs of Growth

In 1956, the gross water revenue was $487,247. Operating costs were $107,201, thus leaving a net balance of $380,046. The water and sewer sinking fund received 32 per cent of the gross revenue, or $156,010, thus leaving a $224,037 balance for general fund operations.

The amount of water pumped has increased from year to year. In 1954, the increase over the previous year was 5.4 per cent; in 1955, it was 8.1 per cent; and in 1956, 26.1 per cent. In 1956, an average of 3,135,443 gpd was pumped at an average cost of $0.05114 per 1,000 gal. On Feb. 26, 1956, only 1,886,000 was pumped—the lowest amount for the year. The highest amount was 4,680,000 gpd, pumped on Aug. 13, 1956.

Another index to the growth of water production and distribution in Gainesville is the number of meters in operation. As of Dec. 31, 1955, 5,244 meters were in service. During 1956, 1,205 new ⅝-in. meters were installed, 360 of which were inside the city limits.

The filter plant installed in 1954 had a capacity of 4 mgd. Additions have been made since then, bringing it to a 6-mgd capacity, and it is planned

eventually to have accommodations to pump 12 mgd. The city has been fortunate in having a mayor and city commissioners with a great deal of foresight and courage.

Extended service to areas outside the city limits was first made available in 1954, but it was not until 1956, when 865 ⅝-in. meters were installed that a peak demand was reached. By the end of 1956, 2,252 meters were in service outside the city. Customers outside the city pay $75 per meter, while those inside pay only $35. The extensions are made in blocs, or areas. There have been 32 of these to the present time. The materials used in the projects are listed in Table 6.

TABLE 6

*Piping Used for Projects Outside Gainesville City Limits, 1956*

| Type of Pipe | Diameter Size *in.* | Length *miles* |
| --- | --- | --- |
| Galvanized | 2 | 32.0 |
| Cast iron | 4 | 1.0 |
| Cast iron | 6 | 29.0 |
| Cast iron | 8 | 12.5 |
| Cast iron | 12 | 1.2 |
| *Total* | | 75.6 |

The procedure in extending service so far has been to have those desiring water submit area bloc petitions listing the number of meters to be installed. Petitions are then examined by the mayor and city commissioners who pass them on to the city manager, the water superintendent, and the installing company to pass on feasibility of installation.

The petitioners or owners of subdivision submit plans of the area and sign contracts stating that they will pay for all materials and installations; it is specified that when 51 per cent of the lots in their area are metered, they will be refunded these installation costs.

Customers outside city limits pay a rate double that paid by those living within the boundaries. Thus, the minimum monthly charge for 300 cu ft, or 2,244 gal, is $1.50 for those living within the limits, while those without pay $3.00.

Cities that are active, alert, and energetic welcome and encourage requests to extend water service into rural areas. This might be considered especially true with cities which do not own electric or gas systems, since extension of water service is one opportunity of convincing residents of surrounding areas that their needs are best served as part of the city.

# Land Policy for Impounding Reservoirs

Francis S. Friel

*A paper presented on May 13, 1957, at the Annual Conference, Atlantic City, N.J., by Francis S. Friel, Cons. Engr., Albright & Friel, Inc., Philadelphia, Pa.*

THERE seems to be a singular lack of information published on the subject of land acquisition and policy. There also seems to be a singular lack of uniformity in the policies adopted by various water works in their land acquisition practice. This paper endeavors to clarify procedures and practices by presenting four divisions of the problem: [1] a classification of land areas for acquisition, [2] the different purposes of land acquisition, [3] the policies of land acquisition which have been adopted at various water works and at other types of reservoirs, and [4] a reasonable land acquisition policy for impounding reservoirs.

For the purpose of discussing the land acquisition policy for impounding reservoirs it is possible to divide or classify the lands into three possible categories somewhat as follows:

1. The reservoir or flooded area including the necessary lands to construct the dam itself and the other appurtenant structures

2. The marginal strip immediately around the periphery of the flooded area at normal and maximum high water level

3. The drainage area or watershed, either wholly or in part above the reservoir.

This presentation will be devoted mainly to the citation of various examples of land acquisition for impounding reservoirs which are generally practiced by the water utilities—both privately and municipally owned—and the development of what is considered to be a reasonable and practicable land acquisition policy. The practice followed in multipurpose reservoirs will also be discussed. But first, it is necessary to describe the purpose of acquiring land under the three categories which have been just set forth.

### Reservoir Area

In the reservoir area it is, of course, absolutely necessary to acquire title to all land which will be flooded when the reservoir is at normal water level, together with all land required for the construction of the impounding dam, the spillway, the intake and other appurtenant structures, access roads, and incidental service facilities.

This flooded area must be cleared of houses, barns, structures, cemeteries, and other possible sources of pollution. As an example of the magnitude that this clearing of the reservoir site can assume, consider the case of the Quabbin Reservoir of Boston's water supply (*1–2*). Fourteen towns were affected to a greater or lesser extent. The reservoir itself occupies some portion of ten of these towns, and four ceased to exist as political subdivisions. There were, also, 34 cemeteries located within the watershed, which were va-

cated. All bodies were removed to other cemeteries located beyond the watershed. It is a most difficult task to acquire land occupied by a cemetery because of the land ownership problem.

Another matter for consideration is the clearing and grubbing of trees and shrubs from the reservoir. The extent of this stripping of the reservoir area will probably depend to a large extent upon the recommendation of the engineer and others in charge of the project; and at times it is governed by the availability of funds and whether the water supply is to be filtered or merely chlorinated. In any event, trees, shrubs, and undergrowth which may project above the surface of the water should be removed. In general, experience has shown that thorough stripping of a reservoir site has improved the initial quality of the water, since the contact of the stored water with vegetation and decaying organic matter has been minimized, but experience has also shown that in time there is little difference between a stripped and unstripped reservoir.

In preparing the reservoir area, it is sometimes necessary to provide for the relocation of bridges, highways, railroads, pipelines, and other utilities. For the Green Lane Reservoir on the Perkiomen Creek, just completed by the Philadelphia Suburban Water Company, it was necessary to relocate and raise a county highway. The cost of approximately $500,000 included the construction of a new reinforced concrete bridge to replace the last remaining covered bridge in Montgomery County, Pa.

## Marginal Strip

The purpose of the acquisition of a marginal strip of land around a reservoir is perhaps not clearly understood, and it may be for this reason that the general marginal strip acquisition policy varies so drastically from place to place.

There are many factors which affect the acquisition of this marginal strip; the governing factor will vary from reservoir to reservoir. For some reservoirs, the preservation of the quality of the supply is the governing factor; in others, it is the control of silting from adjacent property; while in others, it may be access to the reservoir.

The degree to which the quality of the water supply should be preserved depends upon the treatment given to the water (*3*). Obviously, much more rigid control of the sanitation of the watershed is required if untreated water or only chlorinated water is delivered for use than if filtration is provided.

Even in the absence of specific legislation, if the utility or municipality owns the marginal strip, the sanitation of a water supply can be preserved by the limiting and regulating of the recreational use of the reservoir area for hunting, fishing, boating, and swimming. This is accomplished by the employment of caretakers to enforce these regulations, provision for adequate sanitary toilets and garbage cans for picnic areas, and imposition of other special regulations which may apply to a particular location. This control cannot be exercised unless the utility or municipality owning the reservoir also owns a marginal strip around the reservoir.

If the reservoir area is to be used for recreational purposes and the various attendant concessions, parking areas, and other facilities are to be provided, then more land is required around the reservoir than would be necessary otherwise.

Farmhouses located on the watershed in the immediate vicinity of the reservoir should have toilets that will not pollute surface water. Barnyards and livestock feeding areas should not drain into surface water flowing directly into a reservoir. Ownership and control of a marginal strip mitigates, to a large extent, possible pollution from these sources.

Various authorities (*4–5*) have stated that as much marginal land as possible should be owned or controlled by the water works for the purpose of reducing insofar as it is practical the silting of the reservoir from erosion of land adjacent to the lake. This factor of silting is, of course, more important on a highly developed watershed than on a relatively undeveloped watershed. The amount of silting will vary with the type of soil, the slope of the land, the amount of protective cover, and by farming practices.

The marginal strip is used for access by water works personnel for the operation and maintenance of the reservoir, and especially for the control of algae and other growths.

The marginal strip could also be planted with evergreens to prevent leaves from deciduous trees from blowing into the water. This practice tends to reduce possible taste and odor problems; in addition, it helps to eliminate clogging of intake structures caused by accumulations of leaves in the fall of the year.

The water works, in order to avoid liability for property damage, should own all property which would be inundated by maximum high water brought about by major floods of record, as well as all property which might be damaged or eroded by wave action. As an alterenative, flood rights might be acquired from landowners.

**Drainage Area**

Due to the continual increase in the demand for high-quality water, considerable concern is often expressed by water works management regarding the problems arising from the increased use of watersheds for commercial, industrial, and agricultural purposes, as well as for the construction of new highways and other utilities. In spite of these increased activities, the need for acquisition or control of a major portion of or an entire watershed is limited almost entirely to those water supplies which are delivered for use without treatment except chlorination.

There are, however, certain reservoirs where land control of a watershed is desirable even when the supply receives treatment prior to its use. Sometimes, in mining areas, the only manner in which a surface water supply can be protected against acid drainage from mines and stripping operations is for the water works to own the entire drainage area. As an example, the Municipal Authority of the Borough of Minersville, located in the anthracite coal region of Pennsylvania, found it necessary to float a special bond issue to finance the purchase of its entire watershed in order to protect its supply from coal mining operations.

Other activities which may impair the quality of a surface water supply are the logging industry and improper agriculture and grazing methods (*6*). It is not economically feasible nor practical to attempt to eliminate such activities entirely from the watershed. It is possible, however, to afford partial protection to the water supply by the use of reasonable protective measures, such as terracing, strip and contour farming, and flood control. The acquisition of an entire watershed is mainly limited

to relatively small drainage areas, but there are also some instances where a large watershed area has been acquired.

The Metropolitan District Water Supply Commission of Boston, Mass., has acquired a land area of 80,920 acres or about 126 sq miles in the Swift River and Beaver Brook watersheds, which area is approximately 68 per cent of the total drainage area of the Quabbin Reservoir. The surface area of this reservoir when full is 38.6 sq miles, or about 21 per cent of the total watershed.

The city authority of Bethlehem, Pa., has adopted the policy of attempting to acquire all of the drainage areas on its two reservoirs. In the Wild Creek watershed, 9,596 acres or about 70 per cent of the entire drainage area of the reservoir have been acquired, and in the Tunkhannock watershed some 3,843 acres or about 30 per cent of the entire drainage area have been acquired. Additional land is being acquired by the authority from time to time as property is offered for sale in these two basins.

Examples of impounding reservoirs in Pennsylvania where the entire watershed was acquired are: the borough of Sellersville, watershed area 0.7 sq miles: the Hanover Municipal Water Works, watershed area 5.7 sq miles; and the Altoona City Authority, watershed area 4.4 sq miles.

Incidentally, the Hanover Municipal Water Works has planted over 1,-500,000 evergreens on its watershed, which was formerly cultivated farmland. This practice has improved the characteristic of the runoff, and dry-weather flows and total flows have been increased.

As an example of how little thought is given by some lay people to the need for preserving the quality of water supplies, consider the bill that was introduced in the senate of the state of Washington in January 1957. This bill would have opened for public use and access for hunting and fishing all real property in excess of 200 acres owned, leased, or otherwise controlled by a municipal corporation as a watershed or drainage basin for a public water system. Fortunately, this bill died in committee.

### Acquisition Policies

The acquisition of land is usually consummated by bargaining between the municipality or utility and the landowner. Occasionally, however, it is necessary to condemn the land required because the asking price is too high, the owners refuse to sell, or some other factor. In most states both municipalities and utilities have the power of condemning land. Sometimes, however, it is impossible to acquire land even by condemnation. In Chester, Pa., the court ruled that the municipal authority could not condemn the land of a Girl Scout camp located near the reservoir because of the nature of the institution involved.

With the acquisition of land often being consummated in the purchase of entire farms or tracts, a portion of which may not be absolutely required, it is sometimes possible to sell off certain portions of the land on a farm, although, as a basic principle, it is wise to hold land once it has been acquired.

The practice of acquiring land for reservoir purposes, especially the marginal strip of property adjacent to the reservoir, differs widely to suit local conditions, as well as economic and financial limitations.

The following examples show how this policy has varied in different sections of the country. It should also be noted that these include examples of

reservoirs used for water supply, hydroelectric development, flood control, irrigation, and recreation.

*Water Supply Reservoirs*

*Philadelphia Suburban Water Company, Bryn Mawr, Pa.* The general policy followed by this company at its Green Lane Reservoir was to acquire a minimum marginal strip of land 100 ft beyond the water line at flood elevation (el 295), on which the design of the spillway of the concrete dam is based. This project was constructed in 1955–56. Statistics are shown in Table 1.

TABLE 1

*Data on Water Supply Reservoirs*

| Item | Green Lane Reservoir—Bryn Mawr, Pa. | Chester Municipal Authority—Chester, Pa. |
|---|---|---|
| Spillway elevation—*ft* | 286 | 280 |
| High-water elevation—*ft** | 295 | 288 |
| Freeboard above maximum flood level—*ft* | — | 12 |
| Watershed area—*sq miles* | 71 | 139.6 |
| Approx. surface area of lake—*acres* | 815 | 620 |
| Approx. land area acquired—*acres* | 2,300 | 1,800 |
| Percentage of land area to surface area | 280 | 290 |

* Based on design requirement of the Commonwealth of Pennsylvania.

*Chester Municipal Authority, Chester, Pa.* The general policy followed in the taking of marginal property was to acquire a 200-ft strip beyond the water line at spillway level and up to a vertical elevation of at least 20 ft above that level. This project was constructed in 1949–51. This is a rolled-fill dam with a side-hill spillway and Tainter Gates (Fig. 1). Table 1 gives statistics on this reservoir also.

It should be noted that the land acquisition policy will be somewhat different when a concrete dam is constructed as compared to an earth dam. A concrete dam has an overflow section, which acts as a spillway, and a nonoverflow section. If the nonoverflow section of this dam is topped with water during a major flood, there is not much likelihood of major damage. On the other hand, if an earth dam is constructed with a side-hill spillway and outlet works, it is fatal to permit such a dam to be topped, and therefore an extra freeboard should be allowed from the top of the maximum high-water level to the top of the dam itself. This means that in the acquisition of reservoir land, a greater vertical distance is required for an earth dam as compared to a concrete dam.

*Board of Water Supply, New York City.* A minimum horizontal distance of 200 ft from the water line at full reservoir level is maintained, but this distance will vary because the area is also cleared for a minimum vertical distance of 20 ft above the water line. The distance from the water line to the actual take line—limit of property acquired—varies, with 200 ft being the minimum horizontal distance.

*Baltimore Bureau of Water, Baltimore, Md.* The high-water level in Liberty Reservoir was calculated to be 8.5 ft above the water line of el 420, setting the high-water line at el 428.5. The take line was established by fixing the high-water line at 1.5 ft above the actual, or at el 430. A minimum horizontal take line beyond el 430 was not established, but in some instances the property acquired extended over 1,000 ft beyond el 430, and in others it was less than 50 ft beyond el 430.

*American Water Works Service Company, Inc., Kokomo, Ind.* The policy followed on the development of the water supply reservoir at Kokomo consisted of setting a limit of the land area take roughly 10 ft higher than the

water line of the reservoir, with the idea that this figure would more than cover any possible 100-year flood elevations.

*American Water Works Service Company, Inc., Mianus River Reservoir, Greenwich, Conn.* In acquiring the land for the Mianus River Water Supply Reservoir, the company was involved in a bistate development—between Connecticut and New York—which complicated the project. In this instance the company set the limits of the land acquisition to allow the raising of the dam at a future date. With a crest elevation of 252 and a maximum flood elevation of 259, the company purchased land up to el 275 and was reasonably successful in doing so, except at the upper end of the Mianus Gorge, a primeval forest area, where nature lovers and bird watchers prevented the company from going above el 260 at the present time. The backwater curve did not require additional elevation at the upper end, since the maximum flood elevation was 259.

*Indianapolis Water Company, Indianapolis, Ind.* The company has acquired marginal land around its two large impounding reservoirs—Geist Reservoir and Morse Reservoir—to the extent that the total reservation area acquired is approximately 300 per cent of the water surface. The distance varies from the water surface to the limits of the whole area.

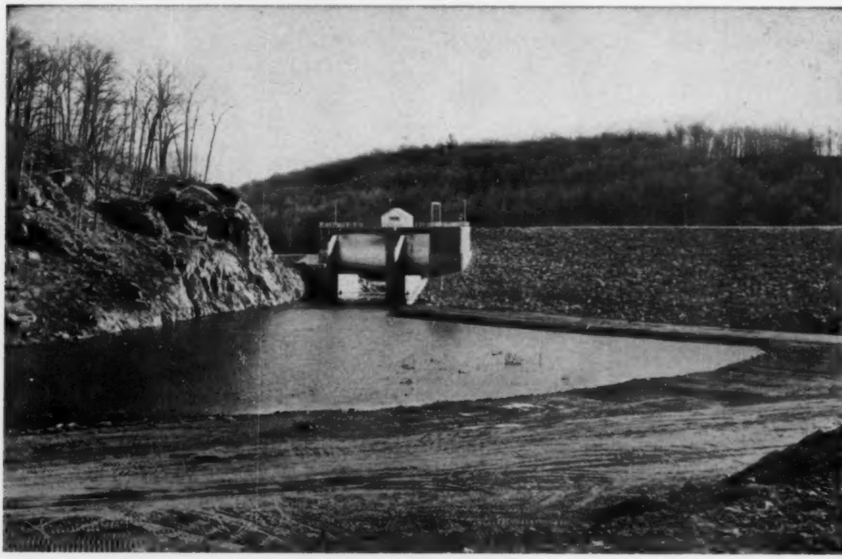

**Fig. 1. Dam and Gates at Chester, Pa.**

*This is an upstream view of the dam on Octoraro Creek, showing the Tainter gates.*

### *Multipurpose Reservoirs*

*Tennessee Valley Authority, Knoxville, Tenn.* The practice of the Tennessee Valley Authority (*7*) in regards

to the take line has varied considerably on different reservoirs. These reservoirs are for multipurpose use, embracing power, navigation, and flood control.

An example of TVA's policy is the Norris Reservoir where every tract of land lying within 0.25 miles of the designed flood stage was acquired, and, in addition, those tracts of land beyond this 0.25-mile limit containing not more than 40 acres were acquired when the owner desired to sell. This policy represented an extreme in land taking which was not reached on reservoirs built subsequently. On the Kentucky Reservoir, land was bought in fee to a backwater line computed from an elevation 10 ft below maximum high water at the dam, and on land lying within this top 10 ft of flow, easements were bought confined to the 6-month period beginning December 1 and ending May 31. This is the season during which major floods may be expected; it is also the season when crop damage from flooding would be relatively small. The Kentucky Reservoir is the only one in which TVA has acquired seasonal flooding rights. This is somewhat of an innovation.

In general, on the earlier reservoirs, TVA acquired a protective strip varying from 200 to 1,000 ft from the high-water contour; whereas, in later reservoirs all land below a contour 5 ft above the high-water line was acquired, thus providing a freeboard of 5 ft for the reservoir pool, which would obviate such water damage as was likely to be caused to adjacent lands by wave-wash, saturation, or occasional overflow.

*Corps of Engineers, US Army.* The Corps of Engineers has followed a policy, in certain instances in the acquisition of marginal strips of property adjacent to reservoirs, of buying in fee simple only up to the water level of a 7-year flood. On the balance required, they take flowage easements.

*Bureau of Reclamation, Grand Coulee Dam, Wash.* The Grand Coulee Dam in the state of Washington, constructed by the Bureau of Reclamation, is a multipurpose dam, supplying power, flood control, irrigation, and recreation. The land acquisition policy (*8*) for the marginal strip in this instance was governed by two factors: a horizontal distance for the take line of 300 ft back from the flood level in the reservoir, and a vertical distance of 20 ft above this high-water line. In certain instances, it was necessary to go beyond these minimum criteria in order to acquire land to prevent landslides into the reservoir.

*Miami Conservancy District, Dayton, Ohio.* The policy of the district, which is concerned with flood control reservoirs, is to purchase the entire area where storage might frequently occur when the reservoirs are filled for flood control purposes (*9*). Flood easements are obtained on lands within the reservoir area at higher elevations where storage is less frequent. Lands and flood easements are acquired either by negotiation with the owners or by the condemnation process under appropriate legislation.

Most of the land acquired by the district has since been sold to new owners, but in the conveying a complete waiver of damages due to flooding was retained as well as the control of the location of structures.

### State Regulations

On September 27, 1956, an inquiry was sent by the AWWA to sanitary engineers in all states, the District of Columbia, and Hawaii. These letters inquired as to regulations of the vari-

ous state health agencies which would apply to ownership or control of marginal lands around impounding reservoirs. A total of 50 replies received was distributed as follows:

1. Two have definite regulations concerning the ownership or control of marginal lands.

2. Eleven states have no definite regulations but do make recommendations.

3. Thirty-seven have no definite regulations and make no recommendations.

Those states with definite regulations concerning ownership or control of the marginal strip are: Arkansas, which requires a marginal strip at least 300 ft horizontally from the lake shoreline at spillway elevation, and Missouri, which requires that when the marginal strip is not owned, an area 100 ft from the water level at spillway elevation is to be fenced around the entire perimeter of the lake, and the area within the fence is to be strictly controlled.

Those states with no definite regulations but who do make recommendations concerning the marginal strip are: Alabama, Connecticut, Iowa, Indiana, Kentucky, Massachusetts, Montana, New York, North Carolina, Texas, and Washington. Most of these states merely make general recommendations to the municipality or utility developing the impounding reservoir, but some do have definite recommendations. For example: Iowa recommends ownership of a marginal strip 100 ft back from the shore line at spillway elevation. Kentucky encourages the purchase of a 200 ft strip around the reservoir. Massachusetts recommends ownership of a marginal strip 50 ft from the high-water mark. North Carolina recommends control to within 50 ft of the shore line. Texas recommends control to 75 ft from the lake surface at spillway elevation.

It should be noted that, although there are relatively few states that have established definite policies concerning the ownership or control of the marginal strip around impounding reservoirs, most of the states do have rules and regulations concerning the sanitation of the watershed as well as the permissible recreational use of impounded waters used for domestic water supplies.

## Conclusions

From this discussion, it is apparent that a definite policy regarding the ownership and control of the marginal strip around an impounding reservoir has not been established by practice. It is extremely doubtful, because of the numerous variables involved, that a definite policy can be established which will apply universally. In this respect, a report by TVA applies: "The type and extent of acquisitions for reservoir projects vary with the general location; the topography; the state of development of the region; the type, use, and value of land contiguous to the shore line; the operating schedule proposed for the reservoir; and conditions peculiar to the particular project." To this list should also be added the use which will be made of the water and the extent of treatment it will receive when the water is used for water supply purposes.

While it is perhaps not feasible to establish a definite policy which will apply in all instances, it is possible to set forth certain criteria which may be used as the basis for determining a reasonable policy for minimum land acquisition.

1. Sufficient land must be acquired for the reservoir water area and for

the construction of the dam and other appurtenant structures.

2. Sufficient land should be acquired so that the water works will be in a position to control access to the reservoir in order to preserve the quality of the supply, giving due consideration to the treatment which the supply will receive.

3. Sufficient land should be acquired for operation and maintenance of the reservoir and for access to water works employees.

4. Sufficient land should be acquired for the protection of the water works from legal liability for property damage resulting from major floods or wave action which might inundate or erode adjacent property.

5. Additional land should be acquired, where economically feasible, for controlled planting of evergreens and cover crops to aid in reservoir operation and the control of erosion, landslides, and silting.

6. A minimum take line approximately 100 ft beyond the maximum flood level in the reservoir, or even greater when economy permits, seems to be desirable. This policy can be modified, and the take line distance reduced, if necessary, to suit individual conditions.

7. Based on experience, it appears that the total land area which has been acquired is approximately 300 per cent of the surface area of the reservoir at the maximum flood line for cases where the water supply is filtered. This policy considers the necessity for acquiring entire tracts of land or farms beyond the marginal take line.

The author wishes to express his appreciation to William T. Savage of the staff of Albright & Friel, Inc. for his valuable assistance in collecting and assembling the data used in the preparation of this discussion.

The author also wishes to thank all of the various engineers, managers, and superintendents associated with water works systems who have cooperated by submitting data pertaining to land acquisition policies.

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## Discussion

### E. Sherman Chase

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The author's paper constitutes a valuable contribution to the general knowledge as to prevailing policies in the matter of watershed ownership by water utilities. The two classes of land acquisition in which variations in policy occur are those related to marginal strips and those connected with areas taken for control of tributary drainage areas.

It is probable that the influence of the early New England engineers and sanitary experts has been a potent factor in determining land acquisition policies in many parts of the country. A rather large proportion of New England water supplies is derived from impounding reservoirs or natural ponds and lakes. Hence it has been possible to depend upon the natural purification effected by long storage supplemented by watershed sanitation to give assurance of proper water quality.

In order to make watershed sanitation reasonably effective, it became necessary for the water utility to acquire marginal strips of land around the impounded sources of supply and to purchase as much of the area tributary thereto as economically feasible. With the advent of chlorination this policy of land acquisition became somewhat less significant. On the other hand the increasing leisure of masses of people and their quest for recreation have led to greater exposure of impounded supplies to contamination by transient recreationists. The automobile and the good roads have made it possible for remote city dwellers to visit once relatively inaccessible sources of supply. Consequently, even where chlorination is in effect, the control by the utility of a reasonable area of watershed is an added safeguard.

Just what is a reasonable area to own is not too easy a question to answer. Precedent is helpful and the author affords information in that respect. It must be remembered, however, that in many cases land acquisitions were made before the adoption of chlorination. The author has referred to the large purchases of land on the Quabbin Reservoir of the metropolitan Boston supply. The writer suspects that these purchases were decided upon prior to the chlorination of the Boston supply.

It must be granted that dependence upon storage and sanitary control resulted in relatively good typhoid records in those cities with impounded or with natural pond supplies. Ownership of substantial areas of watershed lands makes possible, however, the adoption of watershed management procedures which also benefit the physical quality of the supply. Establishment of stands of evergreens in place of deciduous trees reduces the color-producing effect of fallen vegetation. In this connection it is interesting to note that a forest of mature evergreens produces about half the fallen leaves that an equal area of mature deciduous trees will produce.

Again in reference to the Quabbin Reservoir, attention is called to the fact that in addition to ownership of the 68 per cent of area directly tributary to the reservoir on the Swift River, the commonwealth owns about 35 per cent of the watershed of the Ware River.

whose waters are diverted to the Wachusett and Quabbin reservoirs. To some extent the benefits of such purchases have been decreased by the recent policy of enticing fishermen to the Quabbin Reservoir as reported in the November 1956 issue of the JOURNAL (*1*). Brief reference may be made to other examples. The Bridgeport Hydraulic Company, which celebrates its 100th anniversary this year, owns about 20,000 acres of the 60,000 acres of drainage area tributary to its four reservoirs. The city of Providence, R.I., acquired about 15,000 acres of the nearly 70,000 acres of drainage area at the site of its Scituate Reservoir dam. About 12,500 acres were

TABLE 2

*Land Takings at Northeastern Reservoirs*

| Reservoir | Area of Water Surface *acres* | Total Land Taking* *acres* | Ratio of Land Taking to Water Surface | Drainage Area *acres* | Percentage of Land Taking to Drainage Area |
|---|---|---|---|---|---|
| Adams, Mass., Bassett Brook | — | 1,662* | — | 1,662 | 100.0 |
| Andover, Mass. | 221 | 31 | 0.14 | 1,729 | 1.79 |
| Boston, Mass.: | | | | | |
| Lake Cochituate | — | 296 | — | 11,240 | 2.63 |
| Wachussett Reservoir | 4,178.7 | 4,893 | 1.2 | 69,600 | 7.02 |
| Cambridge, Mass., Hobbs Brook & Stony Brook | — | 618 | — | 15,110 | 4.09 |
| Fall River, Mass.: | | | | | |
| N. Watuppa Lake | — | 3,040* | — | 4,060 | 75.0 |
| New Bedford & Taunton (joint rights) | 5,760 | 656 | 0.11 | 32,000 | 2.05 |
| Groton, Conn., Ledyard | 120 | 416*† | 3.5 | 3,372 | 12.0 |
| Hackensack Water Co., N.J. | — | 1,400 | — | 73,000 | 1.92 |
| Johnstown, N.Y., main supply | — | 1,200 | — | 1,952 | 61.4 |
| Newark, N.J., Pequannock Res. | — | 27,500 | — | 40,400 | 68.1 |
| New Bedford, Mass., Quittacas Ponds | — | 1,800 | — | 7,680 | 23.4 |
| New York, N.Y.: | | | | | |
| Ashokan Reservoir | 8,180 | 7,042 | 0.86 | 164,600 | 4.27 |
| Schoharie Reservoir | 1,145 | 1,227 | 1.07 | 201,000 | .61 |
| Kensico Reservoir | 2,218 | 2,282 | 1.03 | 14,100 | 16.17 |
| N. Jersey Water Dist., Wanaque supply | 2,430 | 3,780 | 1.55 | 60,500 | 6.25 |
| Pittsfield, Mass.: | | | | | |
| Cleveland Brook | 147 | 690* | 4.7 | 9,024 | 8.0 |
| Upper Sackett Brook | 21 | 640*‡ | 30.5 | 640 | 100.0 |
| Port Jervis, N.Y., main supply | — | 1,800 | — | 3,520 | 51.2 |
| Providence, R.I., Scituate Reservoir | 3,600 | 11,400 | 3.17 | 59,400 | 19.2 |
| Salem-Beverly, Mass. | 280 | 440*§ | 1.6 | 550 | 80.0 |
| Saranac Lake, N.Y. | 224 | 44‖ | 0.19 | 1,780 | 2.47 |
| Springfield, Mass., Little River Supply | — | 8,422 | — | 31,100 | 27.1 |
| Worcester, Mass.: | | | | | |
| Several streams | 1,034 | 2,706 | 2.61 | 14,400 | 18.8 |
| Quinapoxet | 295 | 1,035* | 3.5 | 12,672 | 8.0 |

* Figures do not include area of water surface, except those marked with an asterisk (*).
† Additional land has been acquired since completion of dam on the tributary stream.
‡ This land was acquired when Lower Sackett Brook Dam was constructed.
§ Receives water pumped from Ipswich River.
‖ This is land owned by the village; the rest is owned by the state.

taken for the reservoir and appurtenant works.

Data with respect to impounding or storage reservoirs are presented in Table 2. This information came from engineering reports and from an article published in 1932 (*2*).

Once upon a time, many years ago, there came to the writer's attention a dramatic example of gross pollution of a reservoir by runoff from an uncontrolled tributary drainage area. A small town in central New York state derived part of its supply from a small impounding reservoir. One winter a farmer heavily fertilized with manure one of his fields adjacent to the reservoir. Late that winter or in early spring, there came a thaw and rain which caused a heavy runoff of melted snow impregnated with manure directly into the reservoir. Within a few days water drawn from taps in the village was dark brown in color, with an offensive odor, and on agitation foamed like beer. The moral of this episode is obvious.

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## *Henry J. Graeser*

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There has been such a variation of land acquisition policies among the various areas of the country that the author's paper should serve well as an evaluation of the factors to be considered.

The author has spoken in more detail with regard to land acquisition policies in the East, where average rainfall is high and a relatively small watershed can be depended upon for a high rate of yield. Illustrating his remarks that local conditions exercise a considerable influence on the policy to be adopted, however, are the Southwest's relatively shallow reservoirs of 50,000 inundated acres. Projects of this size highlight the cost of land acquisition and place acquisition of shoreline property in a category to be closely evaluated against the benefits to be derived from recreation or reservoir control.

In deciding on the land acquisition policy for one new reservoir under construction, the desirability of a border control strip was recognized. The take line to any specific vertical elevation above spillway in fee simple is decided, however, by economics rather than by arbitrary choice. Thus, a minimum horizontal distance of 200 ft was agreed upon for fee simple purchase, but a vertical take line 9.6 ft above spillway was selected, on the basis that land would be bought in fee simple only if flowage easement could not be obtained at significant savings. There is an estimated 11,000 acres of land between the maximum take line and spillway elevation on this particular project. Thus, it becomes rather hard to justify the purchase in fee simple for control of reservoir use, since the use of the lake surface itself can, undoubtedly, be controlled and the only economic factor to balance against this cost for purchase in fee simple is the income from permits for commercial enterprises along the lake shore. Also, in eastern communities, where it has been the policy to use impounded waters without filtration plants, the sanitation factors take on vital importance. Southwest-

erners look with envy, however, upon the small watershed involved in some of these areas. One of the local reservoirs yields 115 mgd, requiring an impoundment of 415,000 acre-ft and covering a surface area of 20,765 acres. The watershed serving this reservoir is approximately 1,658 sq miles. Located in the watershed are several communities whose sewage treatment plant effluent must of necessity drain into the lake. It can be readily seen then that the sanitation problems presented by individual residences or commercial enterprises near the lake cannot justify any appreciable economic expenditure in the face of the vast area involved in these watersheds. Main efforts are directed towards obtaining satisfactory sewage treatment at the municipalities in order to reduce the organic load in the reservoirs. Even here though, the towns of 2,000–5,000 people do not present a serious problem, with the dilution afforded by these reservoirs and with the modern filtration plant to treat the impounded supplies.

Actually, in the writer's opinion, only a very minimum border of land above spillway elevation is necessary to control access to the lake and the 200-ft horizontal distance can well be reduced to 50 ft. The balance of the land to the maximum designed water surface plus an additional vertical distance to allow for wave action should be acquired on a flexible policy, based entirely on the economics of flowage easements or fee simple purchase, whichever would be the cheaper.

There is a wide variation in the cost ot flowage easements and it is understood that the Corps of Engineers has found that flowage easements cost from 15 to 95 per cent of purchase in fee simple. It seems, however, that a stated policy in fee simple may offer some very good bargaining power if a farmer, balking at selling some of his bottom land, could be offered the opportunity to use it as grazing land for the majority of time under a flowage easement. Naturally, each piece of land involved would require a separate consideration, and the cost would depend on the quality of the appraisal and land acquisition staff involved for a project. It has been found to be most desirable to leave land acquisition policies as flexible as possible, since Texas laws require that condemnation proceedings for property be tried in the county in which the land is located. Thus, a large city condemning a farmer's land in his exclusively rural area cannot expect kind treatment in a local court. The land acquisition which cannot be settled amicably will be both time-consuming and expensive.

# Public Access to Lands Surrounding Impounding Reservoirs

## *Panel Discussion*

*A panel discussion presented on May 13, 1957, at the Annual Conference, Atlantic City, N.J.*

## Recreational Use in Indianapolis—*Daniel P. Morse*

*A paper presented by Daniel P. Morse, Exec. Vice-Pres., Indianapolis Water Co., Indianapolis, Ind.*

THE problems presented by public recreational activities on reservoirs and reservoir lands are many and variegated, but they usually can be solved or minimized by a judicious blend of indulgence and restraint.

Too often are the words in the title of this paper transformed by a combination of a headstrong public and lax or slipshod enforcement of necessary rules and regulations from public access to public excess. That may seem to be merely a matter of enunciation, but it could lead to denunciation, unjust though it might be, of the water company or department involved.

The geographical location of the water company and its reservoir is an increasingly important factor in the problem of public recreational uses of reservoirs and the watershed in general.

There has been a marked increase in the popularity of water sports, not only fishing, but also powerboating, water skiing, aquaplaning, and associated activities. Indianapolis residents are well aware of this tremendous increase, as their first reservoir went in service 14 years ago and the second just last year.

In those cities situated near or within easy driving distance of large rivers, fresh-water lakes, or the ocean, the water companies should not be overplagued with requests for extensive recreational facilities and activities, but those companies located inland and quite distant from natural large bodies of water can be expected to receive the brunt of adverse opinion from water sportsmen if too stringent prohibitions are set up.

Indianapolis quite properly can be included in the inland group. For years this city bore the appellation of "the largest city in the United States not located on navigable water." The last census removed it from that dubious distinction, as the title was yielded to Dallas, Tex.

Today, though the chief sources of supply— White River and Fall Creek —are augmented with an impounding reservoir on each stream, they still are not adjudged navigable. They do have a dependable supply of water amounting to 95 mgd.

In those days before reservoirs, the flows on White River dropped to as low as 25 mgd and on Fall Creek 5 mgd, a total of 30 mgd, compared to a demand of over 50 mgd on hot summer days. Finished water storage and

wells provided the difference. They could not do so with the present day demands. These streams were used whenever possible for boating, which wasn't often. The majority of boaters journeyed to lakes in the northern part of Indiana and even to Michigan and Minnesota for their outings.

### Reservoir Background

A brief history of the Indianapolis reservoirs might be in order. Their story is one which is duplicated in other water operations—a story of planning ahead. The earliest mention of possible reservoirs came before the turn of the century, with a watershed survey. In 1921 the firm of Metcalf and Eddy began an overall study of the future water needs of the Indianapolis area and the plant additions necessary to supply that water.

Two reservoirs were suggested as a result of the survey, one on Fall Creek, another on the White River watershed. Some land was purchased for the Fall Creek Reservoir and plans were drafted, but the depression of the 1930's deferred the work. War clouds in Europe in the late 1930's, however, caused renewal of the planning. Hand in hand with the reservoir were plans for building a filter plant for the Fall Creek system to utilize to the fullest the reservoir potential. Both residential and heavy industrial expansion were increasing rapidly in the area to be served by these facilities. The filter plant was constructed to half of its ultimate capacity in 1941. It has since been doubled. The reservoir got under way that spring.

Even before work began, the state conservation department requested that consideration be given to allow the department to operate the reservoir as a state park. After careful consideration, the management decided otherwise, primarily due to its desire to be able to exercise unhindered control over the water supply.

Likewise, a proposition came from a high-pressure salesman, who wished to lease the entire shoreline and acquire water surface rights to the reservoir to use it for a summer resort, with a floating dance palace and all the honky-tonk trimmings. He promptly lost interest when he learned that the water level would not remain constant, but would drop as the public's demand for water dictated, even perhaps to the original creek channel.

### Geist Reservoir

The reservoir on Fall Creek filled on March 17, 1943. It was named Geist Reservoir in honor of Clarence H. Geist, who was president of the company from 1913 until his death in 1938. Its capacity is 6.9 bil gal, its surface area full is 1,800 acres, and it is listed as the third largest "lake" in Indiana. Marginal land around the reservoir totals slightly more than 3,600 acres. The shoreline measures 35 miles, and the depth of water at the spillway is 26 ft.

The management was fortunate in the timing of the first reservoir insofar as the public demand for recreational facilities and use was concerned. With the war, gasoline and tire rationing was quite stringent, and there was scant leeway for the fishermen and boaters to frequent the reservoir, which was 16 miles from Indianapolis. Therefore, the public generally did not find the reservoir for nearly 7 years—time for management to study carefully plans for public use.

Shortly after the reservoir filled, the company received an unusual request, unique at that time anyway. An Indi-

anapolis resident, prominent in national aviation circles, asked for a lease on part of the water surface so he might take over the dealership of an amphibious plane, establish his office at the dam, and operate a charter service. He was turned down because the venture might have proved dangerous to boaters and to planes, owing to fluctuating water surface area and sandbars.

**Fig. 1. Fishermen at Geist Reservoir, Indianapolis**

The company formulated rules governing the recreational uses of Geist Reservoir consistent with its primary purpose of providing a water supply. Fishing (Fig. 1) was permitted all along the shoreline, prohibited only at the dam and spillway. No hunting or shooting was allowed, primarily as a safety precaution due to the many nature study groups using the area. The company equipped many beautiful scenic spots for picnic areas. These are used extensively, and although their use involves some manpower for cleanup, the many compliments and "thank you" notes received make them a real public relations asset (Fig. 2).

At this point it should be made quite clear that both reservoirs are several miles north of the city limits of Indianapolis. Water, after storage in the reservoirs, is released to the stream, and flows down the stream 16 miles in one case and nearly 25 miles in the second to the points where it is taken out for complete filtration treatment and delivery to the distribution system. The reservoirs are, in a sense, primarily regulatory reservoirs, storing water at times of heavy rainfall and delivering water as required at times of low stream flow.

There is a sharp difference between this situation and practice and that which occurs, for example, in Boston, New York, and other places where

stored water receives no treatment other than chlorination and flows directly from reservoir to distribution mains. Therefore, Indianapolis personnel are keenly aware that their approach to public use of the reservoirs is possible, because of their own particular situation and, obviously, could not be copied 100 per cent by others facing different problems. Boating was prohibited primarily because of the possible liability involved, but in war days this did not represent a problem in enforcement. The purchase or lease of land for summer homes likewise was taboo, for several reasons. These included: the sanitation angle, which was largely psychological; a wish to allow the general public free access to all the land adjoining the water; and the undesirability of such would-be cottagers or homeowners facing an increasing stretch of unsightly and possibly odorous exposed reservoir bottom as the water level dropped during time of heavy demand. It might rightly be concluded that this last reason was the major talking point in discouraging interested purchasers.

Resistance to lease or sale of land for cottages adjacent to the water area has continued. A reservoir by its nature would sooner or later present serious problems for those who had constructed docks. Private use would also exclude much public use, and in light of experience it is believed that local policy has been sound. Probably the development of private facilities around reservoirs also increases the danger of strong pressure from such groups for holding reservoir levels up to their needs—hampering freedom to manipulate reservoir levels as needed for public water supply purposes.

## Recreational Use

During World War II an interesting violation, not objected to by anyone, was the use of the reservoir area by a nearby Army base and Air Force base, whose forces used the area frequently for maneuvers and bivouac, as well as for testing amphibious jeeps and trial landing of gliders to determine floating time. The years after World War II, with their increased leisure time, produced more and more fishermen and

**Fig. 2. Picnic Area at Geist Reservoir**

boaters, with a resultant increase in queries concerning use of boats. The number of trespassers multiplied, and in 1953, the management decided to permit operation of a fishing boat concession on Geist Reservoir. It was decided that it should be operated not by the company but by a private concern under lease agreement.

This announcement made considerable news in central Indiana. An indication of the interest is shown by the fact that when prospective concessionaires

were asked to submit proposals describing details of their proposed operation, including liability coverage, about 100 requested information and about half of those submitted firm bids with detailed architectural drawings. The group selected has performed its function in excellent fashion. The fine operation, well equipped and courteously managed, has made many friends for the company.

It may be of interest that among the items covered in the agreement between the company and the concessionnaire

**Fig. 3. Main Line Dock, Geist Reservoir**

were: public liability for the dock company to a limit of $200,000 for any one person, a limit of $500,000 for any one accident, and property damage coverage to a limit of $10,000. The water company also was protected under the provision for contractual liability.

The concessionnaire constructed attractive rustic buildings, necessary roadways, parking areas, and docks, after approval of design and other incidentals by the company. The agreement permitted rental of boats, to be not less than 12 ft or over 18 ft in length, and motors of 5½ hp or less. They now have 135 boats and 60 motors for rent (Fig. 3). They provide repair service, fishing tackle, light foodstuffs, clothing and equipment storage lockers, and other supplementary services, all approved by the company as to scope and charges. No changes in their operation can be made without prior approval of the water company.

Some method of control over the persons using the reservoir was deemed necessary, and a simple permit system was instituted. These permits were made available free of charge by the company in its offices and also, for convenience of the public, at sporting goods stores, bait houses, and hardware stores within a radius of about 40 miles of the reservoir. There are several small towns of 5,000–10,000 population in this radius, and the permit business boomed. At the start of permit issuance they could not be obtained at the dock itself, as it was felt that the water company would be more closely identified with the permit and the recreational uses of the reservoir if obtaining a permit were not made too simple. Now that the public is well aware of the company's ownership and the fact that they are enjoying its use through its courtesy, personnel at the dock are allowed to issue permits. All advertising by the dock includes reference to the water company's reservoir. Provisions of the permit included the waiver of liability, but fortunately this has never been a matter of legal concern. Permits are issued only to persons 16 years of age or older. The rules included: no use of private boats, no hunting, the use of private motors within horsepower limits, no building of open fires (outdoor ovens are provided), no swimming or bathing, no

throwing of trash, no camping, no entering of posted areas, and, naturally, no excessive use of intoxicants. The rules were obeyed much better than anticipated. Only a very few of the approximately 30,000 permits issued each year have been revoked.

In the agreement with the dock corporation, the water company was very explicitly not bound to maintain a specific water level in the reservoir, nor was it held responsible for keeping it stored with fish. The Indiana conservation department has been exceedingly cooperative in this respect. The dock corporation has also stocked it.

The company has the right to inspect buildings, equipment, and financial records, and to have discontinued any practice deemed unsafe or undesirable. As mentioned, fees were approved by the company, because, obviously, exorbitant rates would reflect against it in some degree.

Water company employees are entitled to a generous rental discount, which has furthered good personnel relations. Also, a secluded area on the shore has been set aside and equipped as an employee picnic ground.

This entire arrangement has worked out satisfactorily for all concerned—the public, the concessionnaire, and the water company. Four years of operation will be observed this summer and Geist Reservoir is pointed to with pride by all law and conservation officials as being the best regulated "lake" in the state. Fishing has been good both from bank and boats, there has been a minimum of reckless boating activities, and trespassing has diminished each year.

## Sailing Club

Another feature of water activity was added to Geist Reservoir 2 years ago—the formation of a sailing club. It received its impetus from a group of men interested in promoting sailing for scouts and other youth organizations. The original movement fell through, but others joined forces and after numerous meetings between company officials and local sailing enthusiasts, lease agreement papers were signed .

The company provided the land on a free-lease basis, the club built exceptionally attractive headquarters on the crest of a hilly peninsula, adequate boat slips were constructed, and Indianapolis was soon a mecca for yachtsmen and just common ordinary sailors (Fig. 4). Again the company was indeed fortunate in its relationship with the sailing club, because the first and succeeding officers have been men of stature and responsibility in the community and membership dues were sufficiently high to avoid a shoestring operation. The club roster is indicative of a fine cross-section of the business and social life of the Indianapolis area. Rules and regulations of the club, approved by the water company, are rigidly enforced and cover practically every contingency. Their training methods and safety requirements are important aids to both the members and the company. Frankly, the author cannot imagine a more dedicated, enthusiastic, and hard-working group than this sailing club, which has received national recognition. It is quite a sight to witness a regatta with more than 100 boats under sail, where so recently corn was growing and no such facilities were readily available. Numerous regattas are held during the summer—the company sponsors one of them—with the shores of the reservoir lined with spectators All their activities make the sports pages of local newspapers and occasionally yachting magazines. Without fail

the company role is mentioned. A national regatta is planned for this summer.

There has been no friction between the fishermen and the sailors. Both groups observe the rules governing passing distance. No fishing is permitted from sailing craft, so the concessionaire suffers no loss of revenue in that way. The sailing club maintains a power boat for patrol and rescue purposes. The company provides a fast boat for use by law officers in patroling.

All has not been on the brighter side, of course. The outboard motor devotees have been quite vocal, especially during the past 4 years, in their desire to put their craft on Geist Reservoir. Some of their insistence probably stemmed from a clamp-down of their activities on White River inside the city, when nearby property owners complained to city officials of the noise and their interference with Sea Scout activities became dangerous.

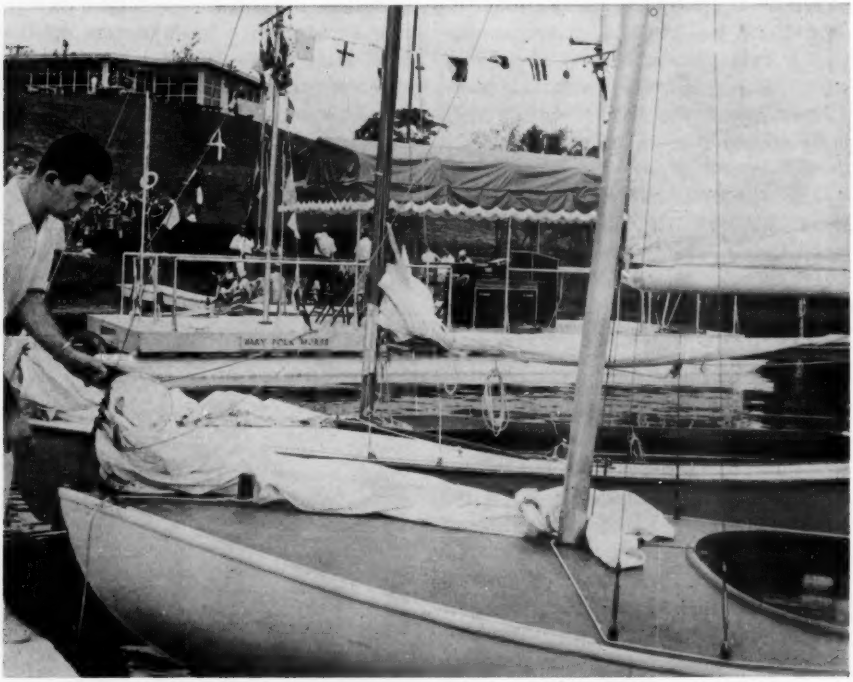

**Fig. 4. Facilities of Indianapolis Sailing Club**

*In the background can be seen the club headquarters, an attractive landmark of Geist Reservoir.*

## Morse Reservoir

This problem is now solved with the completion of the second reservoir. It was mentioned earlier that a reservoir was recommended for the White River watershed by the 1923 survey. Two years after completion of Geist Reservoir, the company engineering staff

began active study for a second reservoir, as it was quite evident that population growth and industrial expansion in the Indianapolis area would soon tax the water supply. Land purchases were begun in 1949 and construction in the summer of 1953. This reservoir is so situated that it impounds the flow of water from three small, flashy creeks. It filled in February 1956, slightly ahead of expectations, due to unusually heavy rainfall. As a sidelight to the filling, a guessing contest as to filling data and hour was held, with cash prizes. More than 1,000 entries were received, and much newspaper publicity and speculation followed.

Dedication ceremonies were held in July 1956, and the reservoir was formally named, by resolution of the board of directors, Morse Reservoir, in honor of Howard S. Morse, who has been associated with the Indianapolis Water Company since 1925.

Morse Reservoir might be considered a twin of Geist in certain respects. Its capacity is the same, 6.9 bil gal; its length just a trifle more, 7.5 miles compared with 7.45 miles; surface area is smaller, however, being 1,430 acres, compared with 1,800 acres. It is the ninth largest "lake" in Indiana. Depth of water at the spillway is 42 ft, compared with 26 ft at Geist. Morse Reservoir presented new and vastly different problems in public and community relations. Whereas Geist was 16 miles north of Indianapolis and several miles from any small community, Morse Reservoir was 25 miles from Indianapolis and just 2 miles from Noblesville, a county seat of 6,000 population. Furthermore, the upper end of the reservoir formed the new boundary of the small town of Cicero, which provoked numerous problems not only in relations with the town's officials but also with its residents and sportsmen.

The management had already decided the new reservoir would be opened to powerboat lovers, and fishermen would be welcome. As one conservation officer said, "The motors won't hurt the fish, but they will really rile the fishermen." Even before the reservoir was finished or completely filled, many boaters were testing out the water. "No Boating" signs were posted, primarily to disclaim liability. As the number of boats increased, officials merely looked the other way.

Company relationship with the Cicero officials and townspeople was somewhat strained, due to a combination of circumstances involving vacated streets, a political election with turnover of officials, and personality problems. A number of open meetings of the town board were held and the problems were eventually solved to mutual satisfaction. The responsible residents of the reservoir area now know that the company intends to handle all problems fairly, and are vocal in its praise.

Negotiations began with several bidders for a powerboat concession, and when a lease agreement was made it provided that the first dock installation should be opposite the town of Cicero to accommodate its citizens. This, together with the purchase of a patrol boat to be used by their marshal in the waters around the town, helped bring about a friendly understanding.

The powerboat concession on the new reservoir was granted a license under the same general provisions as that on Geist Reservoir. Public liability insurance was increased to \$200,000 for each person, \$1,000,000 for each accident, and \$50,000 for each occurrence of property damage. It was felt the powerboats constituted a considerably greater hazard. As the facilities on Morse Reservoir provided for use of private boats, concessionnaire's fa-

cilities included a rustic clubhouse with lunch facilities, docks, launching ramps, open and covered boat stalls, boat hoists, sanitary facilities, large parking facilities, and family picnic areas. All boats rented or launched by the concessionaire must bear a number, clearly legible from 200 ft.

The type of activity on Morse Reservoir is greatly different from that on Geist: high-speed boating, skiing, and aquaplaning. Thus, it was felt necessary to establish certain areas for the various activities. This reduced accident hazard and allowed for better safety patrol. It confined high-speed boating, and set aside certain areas of the reservoir for the fishermen. This matter of clearly specified activity areas received much commendation from local sports writers, and thus has been easier to enforce. Maps are provided to each boater so there can be no misunderstanding of the areas and regulations. Large signs are posted on the bridge structures which separate these areas, and they can easily be seen.

The permit system is the same for both reservoirs. As a matter of fact, the permits are now issued for use at both. Rules on the back of the permits were extended and rephrased to cover activities on both bodies of water. Safety rules are included.

The Morse dock concessionaire operates a constant patrol to insure compliance with all regulations. Thus far dock personnel have performed creditably, and all indications are that their operations will be conducted in a thoroughly responsible manner. They are now completing their second and largest installation near the center of the reservoir. There are extensive facilities, and often more than 600 boats are launched on a single good day.

Recently, an agreement was signed to permit a powerboat club to operate on Morse Reservoir much as the sailing club operates on Geist. Although this club will not construct its clubhouse for some months, launching facilities will be available to its members. Certain restrictions were placed on this club in order to minimize the likelihood of its substantially reducing the income of the concessionaire.

Another public and community relations plus was gained when, in the process of land acquisition, an attractive log cabin located on one of the farms was spared by full reservoir level. Water came to about 30 ft from the cabin's front door. It is well equipped and is, on request, used by responsible organizations in the Indianapolis area, such as Chamber of Commerce directors, USGS employees, engineering associations, and other groups with whom the water company comes in contact. These groups use the facilities as company guests, and particularly because Indianapolis is starved for lake scenery and water activities, this facility is appreciated.

Experience has shown that the best insurance for noncontroversial recreational usage of a reservoir and its shoreline is to take extreme care that persons entrusted with such activities are thoroughly responsible, top-flight people, responsible from the financial stability and liability standpoint. With a clear understanding and acceptance of the rules and regulations established by the water company and of the privileges permitted, if the people are top-notch—and obviously that is the company's responsibility—then worries are apt to be relatively few indeed and officials can sit back and bask in the reflected glory. People who experience pleasant times as guests naturally are more apt to think pleasant things about the company.

## Seattle Watershed Access Policy—E. Jerry Allen

*A paper presented by E. Jerry Allen, Asst. Supt., City Water Dept., Seattle, Wash.*

The source of Seattle water supply, Cedar River, is similar to many of the rivers in the Puget Sound Basin, being relatively short, 40 miles from source to mouth; rising in the higher altitudes of the Cascade Mountains at Yakima Pass, an elevation of 2,500 ft; and modest in character, as evidenced by a 52-year average flow of 692 cfs.

Cedar River (Fig. 5), like most Puget Sound Basin rivers, is fed from the melt of winter snows. The high precipitation normal to the mountain areas results in high discharges per square mile of drainage area.

The Cedar River watershed varies in elevation from 520 ft at the water supply intake to 5,500 ft at the crest of the Cascade Mountains some 25 miles east from the intake. The watershed drainage area comprises 143 sq miles, covered almost entirely with an evergreen forest. The soil structure is mostly of glacial till with a few shallow pockets of loam. Within this mountainous watershed area there is no habitation, neither are there any highways or public roads. Consequently, it is an environment with practically no danger of sewage pollution. This condition is not particularly unique, since the mountainous areas of the Pacific Northwest are normally very sparsely settled and highways are few and far between. The larger cities, that could create pollution problems, are in most part located at tidewater on the shores of Puget Sound.

By comparison with other areas of the nation, Seattle is blessed with a water source naturally free from many of the health and water quality hazards confronting other municipalities. Such was not always so, because for many years the city took its water from Lake Washington, a fresh water lake 20 miles in length and 2 miles wide, abutting the city. The people of Seattle early chose to abandon the lake supply of variable quality and bring water of a consistently high quality, which required only chlorination, from a mountain source.

### Restricted Access

Historically, Seattle has followed a watershed protection policy of restricting access into the watershed area. To accomplish this restriction the city has engaged in the acquisition of watershed lands, through purchase, condemnation, and donation. The present land ownership is city 71 per cent, private and federal government 29 per cent. Eventually 100 per cent city ownership will be accomplished without further cost to the city through land exchange with the federal government, and by reason of existing agreements with private owners.

Seattle has always held that multiple use of watershed areas is a reasonable policy, but only insofar as such uses are compatible with the primary purpose of water supply. Such a compatible use in this area is production of forest products. The Cedar River watershed is capable of producing a sustained yield of 35,000,000 fbm of timber annually, with a 110-year growing cycle. Translated into the economic import to the community, that is the equivalent of 5,000 five-room houses per year. In this day of power equip-

ment and sustained employment, the required logging personnel are far fewer in number than was the case when logging was by hand chopping. Almost to a man the logging employees are family men residing in nearby communities. Contrary to the sportsmen, who by nature of their activities roam singly or in pairs over great areas, logging personnel in most part work in groups. Portable sanitary facilities are maintained in locations convenient to such groups. The incentives of their paychecks and continued employment cause the logging employees to observe established sanitary regulations.

**Fig. 5. Cedar River, Source of Seattle's Water**

Seattle is presently developing a new water supply source, the Tolt River, also in mountainous country. This source will have its impounding reservoir at el 1,765. The Cedar River primary reservoir, Morse Lake, has a spillway elevation of 1,565 ft. The Tolt River source, like the Cedar River source, will be a gravity-flow supply to the city. As with the Cedar River watershed, the policy for protection of the Tolt water source will be restricted access to the watershed, with use limited to timber production.

Probably because of declaration of such intent, some groups seeking special privilege have expressed themselves to the effect that hunting and fishing should be permitted in the watershed area. Recreational use is not compatible with proper protection of water supply under the natural

watershed environment of the Pacific Northwest.

Out of the state's total area of 67,000 sq miles, the combined Tolt and Cedar River watersheds (above water supply intakes) utilize 208 sq miles. This amount of watershed area, utilized as a water source for the more than 25 per cent of total state population served by the Seattle water system, is small indeed.

## State Regulations

Because population densities, river or reservoir environment, and ease of access to available recreational facilities vary so greatly in the many sections of this nation, any attempt to apply a common policy for recreational uses of public water supply sources is ill-advised.

Some waters require complete treatment regardless of recreational or multiple use activities at the source of supply while others do not. Some state laws and regulations require certain specific controls or ownership of marginal reservoir lands, and others do not.

The state of Washington has seen fit to assess a specific legal responsibility to all persons having charge of a water works providing a public water supply. The law reads as follows: "Every owner, agent, manager, operator or other person having charge of any water works furnishing water for public or private use, who shall permit any act or omit any duty or precaution by reason whereof the purity or healthfulness of the water supplied shall become impaired, shall be guilty of a gross misdemeanor."

The state of Washington does not require that either ownership or control of marginal lands rest with the water supplier. There are, however, state laws defining, enumerating, prohibiting, and establishing means of abatement of public nuisances. Also state laws specifically prohibit deposit of unwholesome substances in waters of the state, exposing people to contagious diseases or polluting a water supply or watershed. Unfortunately, such laws require the usual legal evidence for prosecution or abatement proceedings and consequently are of little value to the water supplier, except in the event of flagrant violations.

The Supreme Court of the state of Washington in *Brown* v. *City of Cle Elum*, a case involving personal encroachment on a city watershed, held that police powers of a municipality cannot extend beyond the corporate limits. Therefore the only means for protection of a water supply is by invoking state laws. Seattle practices its belief that the most certain method of protection is ownership or control of marginal lands or watershed, the proper legal posting of the boundaries against trespass, and immediate arrest and prosecution in Justice Courts by patrolmen who are deputized as officers by the county sheriff.

To those engaged in furnishing public water supplies, it is most difficult to comprehend the lack of understanding often evidenced by groups promoting recreational use of watershed areas without consideration of the public health aspects.

During the 1957 session of the Washington state legislature, a bill was introduced to open to the public all streams or lakes whose waters were used by a municipal corporation for public use and all watersheds of a public water supply, for public use and access for hunting and fishing. The bill stated that public use and entry did not constitute an offense against the purity of the water if public use and entry

were in accord with regulations to be promulgated by a special board created by said bill. The board created by this bill would establish the director of game as chairman, with the director of conservation and director of health as the other two members. The duties of the board were established as promulgation of rules and regulations for public access, hunting, and fishing on all watershed property in excess of 200 acres controlled by a municipality. Very fortunately, this bill was killed in committee.

Water works men in Seattle are most appreciative of the active opposition to this bill by the local ASCE chapter, the local professional engineering society, the King County Medical Society, the AWWA, and many of the state's water utilities.

Multiple use of waters, marginal lands, or watersheds should be considered primarily on the basis of compatibility with the highest use to be made of the water. Waters whose natural quality at point of diversion require only partial treatment or simple chlorination should not be exposed to any additional potentially contaminating environment, unless the water utility believes that such auxiliary use or other extenuating circumstances justify the necessary additional treatment required to provide a safe potable water for the public.

## East Bay District Policy—*John W. McFarland*

*A paper presented by John W. McFarland, Gen. Mgr., East Bay Munic. Utility Dist., Oakland, Calif.*

The total subject of recreation in reservoirs is much too large for a complete presentation in this paper, as well as beyond the experience and ability of the author to present completely. Further, the real interest in this subject is focused on one phase only at the present time, and that is fishing. In recent years, the real emphasis has been on fishing in reservoirs, and therefore this discussion will be confined largely to the policy of the East Bay Municipal Utility District concerning fishing and related activities in domestic water supply reservoirs. This is the particular use of reservoirs about which controversy has raged; there is much less debate regarding the recreational use, including fishing, of reservoirs that are designed for flood control, irrigation uses, or other multiple purposes.

A more complete coverage of the subject will be found in the proceedings of a conference in Richmond, Calif., on Dec. 13–14, 1956 (*1*), which gathers together in one place the most current thinking from all sides on the total subject of recreation in reservoirs, not confined to fishing, and not confined to domestic water supply reservoirs.

Fishing is good in California. During recent vacations in the Sierra area, particularly at Fallen Leaf Lake, the author has noticed a greater abundance of fishermen (and fisherwomen) than ever before. This is due in great measure to the fish and game department's program of planting catchable fish.

The methods and procedures of fishing appear to have changed along with the greater interest, and perhaps that is a sign of changing times and a new approach to the recreation afforded by fishing. It is common nowadays for the fisherman to drive along the shores of a lake or stream to a parking place

that will require the least amount of effort to begin to fish. The fisherman settles down for the day, quite often staying in one place and quite often with a folding chair. He has his lunch basket and refreshments close by. He is usually equipped with $50–$100 worth of new equipment, with tackle, spinning gear, and all of the latest gadgets that go with it. He is happy to catch fish of nominal size, usually 6–8 in. Now and then during the day someone will catch a 16-in. or 18-in. trout weighing a couple of pounds, and this seems to provide the incentive for all to keep at it.

The attitude of water purveyors in general toward fishing is not arbitrary and perversely negative. Most of the water purveyors are themselves fishermen and true sportsmen. They do not object to fishing as such. Their opinions regarding fishing in domestic water supply reservoirs are based upon their obligation to the public to deliver a safe and potable supply of water. They know that there are two sides to the story, and they feel strongly that the public has the right to hear, and should be made aware of, both sides of this story. In the past the author has attended public hearings at the state level in which the testimony of water purveyors and sanitary engineers was belittled and cut short on the grounds that "everybody knows that sanitary engineers are opposed to fishing in the reservoirs, so it isn't necessary to hear any details from them."

The attitude of water purveyors in general is that they favor closed watershed areas and closed reservoirs of domestic water. There may be some few exceptions to this, but in the main throughout California and throughout the United States this is the opinion of domestic water supply purveyors. It is the policy of the East Bay Municipal Utility District (EBMUD) to have closed reservoirs and watershed areas, and this means areas closed to all, the public and the employees of the district alike. Often, officials have been accused of keeping these areas closed in order that officials and families of the district can enjoy better facilities. No official or employee of the EBMUD, however, has ever been given any special privileges in watershed areas or reservoirs.

### Public Health Factor

The reasons why water purveyors favor such a policy are two-fold: public health and water quality. Regarding the public health factor, water purveyors are not doctors and they are not health officials. In their communities, they look to doctors and health officials to guide them in the matter of protection of the water supply. There is no question about the fact that health officials generally oppose fishing in domestic reservoirs, and in all instances will certainly put the protection of the water supply above any other consideration. The EBMUD has often sought the opinion of its local health officers, and they have been unanimous in endorsing the district policy of keeping these areas closed. The principal reason for the health officials' attitude is that waterborne diseases, such as cholera, typhoid, and dysentery, are carried only by man, and therefore it is man and his activities that must be guarded against in watershed areas. Animals do not present the same hazard.

Sanitary engineers professionally oppose fishing in domestic water supply reservoirs. This is a doubly difficult attitude for sanitary engineers to take, because it poses a possible challenge to their technical treatment skills. It is a

sanitary engineer's job to provide the treatment that will make almost any water supply safe. Therefore, they instinctively might lean in the direction of claiming that their skills could correct any possible pollution of a water supply. Those very skills, however, give them a knowledge of the limitations and shortcomings of water treatment. There are some few bacteria and viruses against which treatment is not an absolute known corrective. Also, treatment facilities are mechanical, and are subject to potential breakdown at the time when they are most needed. For these reasons, sanitary engineers professionally oppose the possible pollution of domestic water supplies through recreational activities. Even though sewage can probably be rendered safe for human consumption to a very great degree by treatment methods, no community would be anxious to use it as a water supply.

In the 1955 session of the California state legislature, there was bitterly fought legislation on the subject of opening domestic water supply reservoirs to fishing. In the closing moments of the session, such a bill was approved. Immediately thereafter another bitter fight started for the veto of the bill. Finally, the bill was pocket-vetoed by the governor. There is no question about the fact that one of the determining influences upon the governor in this action was the recommendation by the California Department of Public Health that the bill was not in the best interests of the public. This does not necessarily mean that the Department of Public Health is opposed to fishing in public reservoirs, because it has given permits in certain instances. It does, though, point up very strongly the importance of the public health factor in any consideration of domestic water supply use.

## Water Quality Factor

Concerning water quality, the supply for the EBMUD is an appropriate illustration, although there are other parallel examples in the Pacific area. The supply for the EBMUD originates as snow in the Sierras in the watershed of the Mokelumne River. It is impounded about 100 miles from the East Bay area (Fig. 6) to which it is brought through closed aqueducts. The investment in this system has reached approximately $70,000,000. In the early days when the question of water supply for the East Bay was being studied, it would have been possible to go a very short distance, pump water out of the Sacramento River, and with treatment similar to that used in other locations render it reasonably safe and potable for domestic use. Why did the district choose to go to the mountain supply at such a tremendous expense? The answer is that the people of this district chose then to have a high quality water supply, even at the highest cost, and throughout the years the people of the district have been determined to maintain that policy. The citizens are aware of their high quality water supply as compared with other areas, they are proud of it, and they are determined to maintain it at the highest level possible.

In the establishment of a high quality water supply such as this, there are four walls of protection that are provided as a safeguard to the public. These are:

1. *Clean watershed.* The original source of water should be as pure as possible. There is no better primary source than mountain snow.

2. *Long storage.* Water tends to purify itself with long periods of storage. Contrary to popular belief, fast-running mountain streams are not nec-

essarily an indication of water purity. Actually, fast-running streams may create a danger in that they carry pollution more quickly from one place to another. It is long periods of storage that provide the second safeguard to the public. These long periods of storage are effected in huge reservoirs such as the EBMUD's Pardee Reservoir that contains about 64 bil gal of pure water.

**Fig. 6. Pardee Reservoir, Source of Water for California's East Bay Area**

3. *Filtration.* The man-made process of filtration through sand is provided to remove foreign matter and turbidity from a water supply before it enters the last phases of the distribution system.

4. *Disinfection.* Almost all bacteria can be killed through disinfection by means of chlorine. The EBMUD chlorinates its water to a very small degree as a last additional safeguard. There is no trace of chlorine taste in the water, such as there is in communities that depend upon chlorination as their only safeguard against a polluted and contaminated supply.

The EBMUD has built all four of these walls of protection. Few other supplies have all four. The people are fortunate to have all of them, and it is an obligation to continue them. There is an analogy in this policy to that which applies to milk supplies. Certainly the public does not depend upon pasteurization only for a safe supply of milk. There are very strict rules and regulations and inspections of milk supplies right from their very source in the dairy, on through the dairy procedures and the shipment of milk to the customer, to make sure that at each step on the way every precaution is taken to assure a safe supply of milk. Water

supplies are just as critical as a basic factor of human existence.

So water quality is extremely important both to the domestic user and to industry. Industry is acutely conscious of the importance of high quality water in many of its processes. Without a high quality, it is necessary for individual industries to institute treatment procedures of their own at high cost. Therefore an original high quality water is one of the principal economic assets. This is true not only in the East Bay area, but many other areas view the problem similarly. One very important similar situation is that of San Francisco, which obtains its supply from Hetch Hetchy Reservoir in Yosemite National Park. Another is that of the city of Seattle, where the supply is obtained from mountainous areas well guarded and protected against trespass and possible pollution and contamination.

The protection of such services should not be confused with that required for water obtained or impounded where there is known pollution. In such instances—flood control waters, irrigation waters, and perhaps some domestic and industrial water supplies—the problem of control is much different and the hazard of recreation proportionately not as important.

**Provision for Recreation**

Some of the problems that face the domestic water supply purveyor have been pointed out, and they justify the general attitude of purveyors in the maintenance of closed watersheds and reservoir areas. The domestic water supply purveyors, however, are extremely conscious of the growth problems in the state of California and the West in general. They recognize that there cannot be adamant stands in the face of the ever-increasing pressure for recreational outlets for the people. They know that there must be give and take in any general situation such as this, and therefore they have come to the realization that a reasonable solution to this problem must be accomplished whereby there can be some provision for recreational use in some reservoirs at the same time as a high quality supply is maintained.

As mentioned before, the policy of the EBMUD throughout the years, since the 1920's, has been to keep all of its watershed and reservoir areas closed. In recent years, however, it has become apparent that perhaps some degree of recreational use was worthy of consideration. About a year ago, Carl Wente, a member of the State Fish and Game Commission, suggested to L. J. Breuner, president of the EBMUD, that they get together with the Department of Fish and Game and representatives of the sportsmen's group to discuss the problem. Wente made no secret of the fact that he favored fishing in reservoirs remote from the metropolitan areas. He also seemed agreeable to the proposition that reservoirs close to metropolitan areas presented a more acute problem, and should remain closed when they were closely tied in to the daily and weekly problem of distributing pure water to the public. As a result of this discussion, a meeting was held, where it was decided that the Department of Fish and Game would make a study of the utility district's Pardee Reservoir to determine the nature of its fish population, the possibility of future fish management therein, and the potential fishing that could be provided there, with an idea that the utility district and others would study these findings to determine whether or not a controlled

fishing operation would be feasible there. Such a study was made with the knowledge of the State Department of Public Health, and a report was written indicating what might be expected. This report indicated that, although the immediate fishing prospects might not be too good, the potential was good, and that a good response could be expected from fishermen if a sound program were developed.

This project was then assigned to EBMUD's supervising sanitary engineer, who began to visit and study areas in California where fishing has been allowed. His object was to study good practice. Based upon the best that he saw, he wrote a preliminary prospectus for Pardee Reservoir. With this prospectus in hand, the utility district began to contact all of the various interested groups and individuals. These included state senators, assemblymen, county supervisors in the counties affected, sportsmen's representatives, local health officials, state health officials, and civic leaders. The proposal to open Pardee under very strict controls, rules, and regulations was well received. Also generally well received was the proposition that the local reservoirs remain closed, although this point obviously will continue to be a bone of contention with the true zealots of fishing.

The current status of this project is that the EBMUD announced its intention, assuming State Department of Public Health approval, to begin to open the Pardee area for fishing in the 1958 season. The original opening will include the stretch of the river in the upper section of the reservoir only. Later, as well-planned facilities can be constructed, the reservoir itself will be made available to shore and boat fishing. One of the problems, among many others, is financing the project. An organization like the EBMUD cannot spend its own money for such a venture. Therefore, the venture must be financed either by other funds or must be self-supporting, or a combination of the two. A study of this problem is also under way.

Thankfully and fortunately, even the strongest proponents of fishing see the wisdom of a slow and careful approach to the opening of Pardee Reservoir. They know that a misstep or an abuse would boomerang and set the program back many years.

The author cannot overemphasize the importance of keeping closed those terminal reservoirs that are close to the metropolitan areas. Terminal reservoirs are built to hold large supplies of water for an emergency. In case of an earthquake, of a bombing, or the rupture of mountain pipelines, these reservoirs would be the only supply for many days, and therefore must be maintained in quality as close to the original as possible. Also, these terminal reservoirs are often used to regulate weekly and even daily fluctuations in demands from the distribution system, particularly during exceptionally hot summer months. Further, these terminal reservoirs are so tied into the distribution system as to permit bypassing of filtration plants in order that there cannot be a bottleneck between the water supply and the customer in an unusual period. For these reasons, it is in the public interest that any legislation on the subject of reservoir fishing during the current legislature include the principle of keeping terminal reservoirs closed. There appears to be a growing agreement among legislators as to the wisdom and acceptability of this principle.

Another very important step has been the establishment by the State Board of Health of regulations for the control of recreational uses of domestic water supply reservoirs. During the last year or so, proposed regulations have been debated up and down the state of California in many meetings. During these hearings, all agencies affected have had an opportunity to make their suggestions. All of them, whether on one side of the question or the other, have learned a lot from these deliberations. They have all learned a little bit about give and take. As a result, there has emerged a set of regulations that appears to be workable and agreeable to all concerned. As adopted on December 7, 1956, they are acceptable to the California Section of the AWWA, and they appear to be acceptable to sportsmen's groups. Naturally, only a period of experience working with these regulations will prove them out. The water purveyors are willing to enter into such a period.

### Reference

1. Proceedings of Conference on Recreational Use of Impounded Water, Richmond, Calif., Dec. 13–14, 1956. Committee on Research in Water Resources, University of California, Berkeley, Calif.

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## Correction

The paper "Biological Oxidation of Hexadecanol Under Laboratory Conditions" by F. J. Ludzack and M. B. Ettinger (July 1957 JOURNAL, Vol. 49, pp. 849–858) contained an editorial error. The charts for Fig. 1 and 2 (pp. 851 and 852) were transposed. The drawing that appears on p. 852 should appear as Fig. 1, "Carbon Dioxide Production With Substrate No. 1" (p. 851); likewise, the drawing that appears on p. 851 should appear as Fig. 2, "Carbon Dioxide Production With Substrate No. 2" (p. 852).

# Experimental Evaluation of 'Water Conditioner' Performance

**Rolf Eliassen and Rolf T. Skrinde**

*A paper presented on May 15, 1957, at the Annual Conference, Atlantic City, N.J., by Rolf Eliassen, Prof. of San. Eng., and Rolf T. Skrinde, Research Asst., both of Massachusetts Institute of Technology, Cambridge, Mass.*

WATER is the most important and widely used commodity sold in this country today. Unfortunately, the chemical and physical characteristics of a particular water cannot be ideal for all purposes for which it must be used. Therefore, to make it suitable for industrial as well as domestic purposes, it must often be subjected to many complex and costly methods of treatment. Each municipality and each industry has a different situation, which may require modifications of the treatment process.

Scientific research and development are continuously progressing toward more efficient and less expensive processes of water treatment. The water works profession prides itself on utilizing the latest discoveries of science and engineering in the thousands of municipal and industrial treatment plants being built or improved each year to meet the increasing demands of modern technology for water of better quality in greater quantities. Evidence of the great strides made in keeping pace with latest research and scientific development is clearly indicated by the tremendous progress made since this Association was founded 76 years ago.

But there are many water consumers who are not willing to wait for scientific development. Their quest has been for a simple and inexpensive device which will solve the universal water-conditioning problem. They would rather take a shortcut and use a unit which they are willing to accept on the basis of unfounded pseudoscientific theory. Eliassen and Uhlig (*1*) have discussed many of the pseudoscientific claims made by manufacturers and salesmen. The statements are liberally sprinkled with technical-sounding terminology calculated to impress prospective buyers of "magic" water-conditioning units.

On Feb. 5, 1954, the Federal Trade Commission issued a complaint against the Evis Manufacturing Company of San Francisco, Calif., for false advertising. The magazine *Science* reported on this case (*2*) in an article entitled "Evis Water Conditioner." The following is quoted from that article:

> The company manufactures a product, the Evis Water Conditioner, which looks like an expanded pipe coupling with a vertical post integrally cast in the center of the internal chamber. The "conditioners" range in size from those that may be fitted into a 0.5-inch pipe to models

that are intended to be fitted into large industrial or marine pipes and in price from $25 for the smallest model to $3,700 for the largest bronze model. All models are made of either zinc-coated cast iron or bronze, and they are "intended to be fitted into water systems for the purpose of beneficially treating and conditioning water."

The task for the government in pressing its charges of false advertising was made more difficult by the fact that the respondents averred that treatment with the "conditioner" did not affect the chemical or physical properties of the water in any detectable way, but only the *behavior of the water in use.*

Hearings were held by a hearing examiner of the Federal Trade Commission. These resulted in a formal order for dismissal of the complaint against the Evis Manufacturing Company on Apr. 26, 1956. On Dec. 31, 1956, however, the commission issued a subsequent order to the hearing examiner to reopen the case to receive further scientific evidence.

The authors of this article know of no scientific principle which could explain any successful action of a unit of this type. The authors agree with that portion of the second paragraph of the above quotation (*2*) from *Science* "that treatment with the 'conditioner' did not affect the chemical or physical properties of the water in any detectable way." But the authors question the validity of claims of the manufacturer of the Evis unit on the ability of this unit to "affect . . . the *behavior of the water in use,*" as mentioned in the above quotation (*2*). The purpose of the work reported in this paper was to evaluate the effects of the Evis Conditioner on the *behavior* of waters of different types by scientific experiments conducted in accordance with standard water works practice.

The more common screw-type Evis Water Conditioner, shown in Fig. 1, allows direct contact between the unit and the water. Another model of the conditioner which merely clamps on the outside of the water pipe is pictured in Fig. 2. In this case the water supposedly being "conditioned" does not even come into contact with the unit! Two of the screw-type conditioners were purchased on the open market by the authors in order to conduct tests on the *behavior* of the waters in use. After the tests, one of the units was sawed in half in order to examine the interior. A photograph of one half is shown in Fig. 3. The threaded connections of this unit had begun to rust quite noticeably during its short period of use for these studies.


*Photo by authors.*

**Fig. 1. Evis Water Conditioner (Screw Type)**


*Photo by authors.*

**Fig. 2. Evis Water Conditioner (Clamp-on Type)**

## Claims by Evis Water Conditioner Manufacturer

The sales promotional campaign of distributors of the Evis Water Conditioner is based upon claims (*3–9*) of soap savings, reduced laundry water requirements, reduced corrosion of metals, improved taste and odor of drinking water, prevention of scale formation in water works structures and boilers, removal of old scale and rust already formed, reduced cost of heating water, elimination of harshness of water to the hands, improved agricultural irrigation, improved food flavors, and other supposed benefits. Many of these claims have been investigated previously by competent and unbiased research workers, but their results have not been published in technical journals. The work reported herein does not constitute a complete evaluation of all of the claims made by the manufacturer of the Evis Water Conditioner, but merely examines some of the claims in the light of comparisons between the *behavior* of Evis-treated waters and untreated waters in tests which are important and well established in the water works profession.

In setting up the test installation care was taken to eliminate electrical disturbances from the Evis Water Conditioner in accordance with the recommendations (*3*) of the manufacturer, who has stated: "The most important single rule which applies to all Evis installations is—make sure that the piping system carrying Evis-ized water is free from electrical disturbances throughout its length. When this simple rule is followed the Evis always performs at its top efficiency because the delicate change of molecular organization established by Evis-izing is then freed from the interference of electric currents."

## Effect of Metallic Cations

*Manufacturer's claims.* The manufacturer claims that the Evis device "makes most hard waters behave 'Tame'!" (*4*); that "Evis conditions hard water by improving its physical characteristics by use of a Special Processed Metal. Nothing is added, no beneficial natural minerals are removed!" (*4*); that it "gives 'soft results' simply by changing the disposition of natural forces already in water.

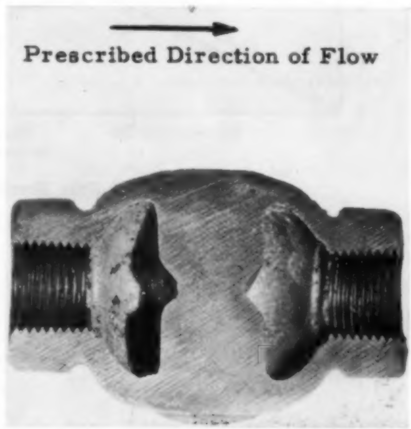


*Photo by authors*

**Fig. 3. Sectional View of Evis Screw-Type Conditioner**

The new disposition prevents stickiness of scales, curds, and sediments" (*5*); "that the functional results of Evis Water Conditioner treated water and those of softened water are almost identical" (*5*).

*Laboratory studies.* Ethylenediaminetetraacetic acid and its sodium salts form chelate complexes with metal cations. This complexing action is the basis of the EDTA test for water hardness. Results of EDTA hardness tests on Evis-treated Cambridge tap water, as compared with plain Cambridge tap water, are summarized in Fig. 4. As

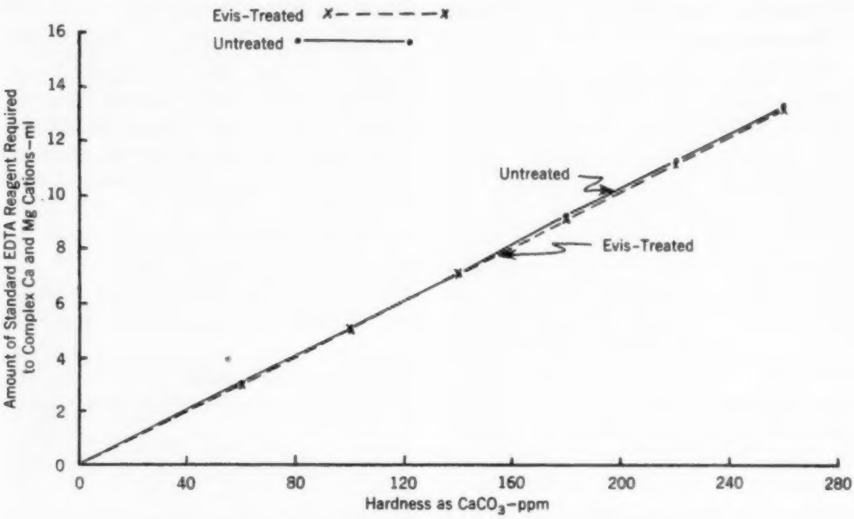


**Fig. 4. Effect of Evis Treatment on EDTA Hardness Test**

*Cambridge tap water with hardness added was used.*

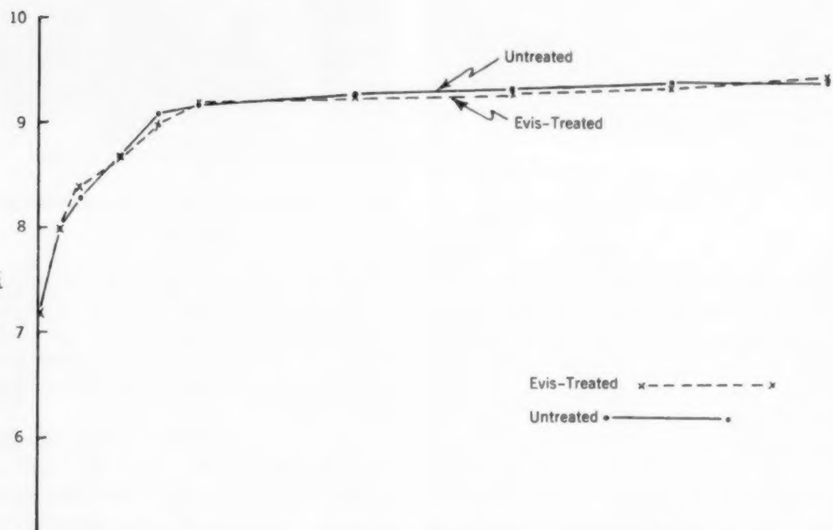


**Fig. 5. Effect of Evis Treatment on pH of Detergent Solutions**

*Laundry detergent was added to Cambridge tap water, which was stirred for 10 min.*

can be seen by the two curves, which can be considered identical within the precision of experimental measurements, there is no apparent change in "the disposition of natural forces" as evidenced by the complexing action in the two waters. Therefore, in this respect, the behavior of the metallic cations is indicated to be unchanged by the Evis Conditioner. It should also follow that soap-consuming and scale-forming properties would not be affected, as these properties are indicated by the EDTA test.

### Laundry Water pH and Soap Requirements

*Manufacturer's claims.* The manufacturer makes, among others, the following claim (*6*) regarding laundry applications in a test comparing Evis-treated with untreated wash water: "During the washing process there is a tendency for soap to lose some of its power. This can be measured by the pH factor. Tests were made at the beginning of the wash and even though less soap was used with Evis water, the pH was found to be the same as with raw water (9.5)."

*Laboratory studies.* The effect of increased or decreased soap consumption in laundry operations by water conditioning is an item of great importance in water works practice. Savings in soap consumption have justified the building of large softening plants in many areas of the United States. To test the effect of adding various amounts of a popular household laundry detergent (made up of alkyl benzene sulfonate and polyphosphates) to Evis-treated and normal Cambridge tap water, a series of controlled studies was carried out. The results of the effect of laundry detergent on the pH of wash waters are plotted in Fig. 5. As may be seen from these curves, the pH increased rapidly up to the amount of 1 g of detergent per liter, and leveled off to slowly increasing pH values thereafter. The two curves showing the effects in both the Evis-treated and untreated waters followed along the same line within the limits of experimental readings. These studies do not confirm the report that the pH would be the same when less soap was used, as stated by the manufacturer. The Cambridge tap water used in these studies had the chemical composition shown in Table 1.

TABLE 1

*Chemical Composition of Cambridge Tap Water*

| Characteristic | Quantity *ppm* |
|---|---|
| Total hardness ($CaCO_3$) | 62 |
| Total solids | 114 |
| Alkalinity ($CaCO_3$) | 24 |
| Dissolved oxygen | 8 |
| Chlorides | 14 |
| Sulfates | 30 |
| Sodium | 9 |
| Silica | 4 |
| Iron | 0.1 |
| pH | 7.2 |

### Standard Soap Consumption Test

*Manufacturer's claims.* "The Evis converts most waters into smoother water. You can taste and feel the difference. And you can see the difference in the dishpan and the laundry! You get richer, longer-lasting suds from your favorite soaps and detergents, and it's amazing how much farther they go in Evis Conditioned Water. Hundreds of users report greatly reduced soap requirements for every sort of household washing. A single box of soap goes a lot farther than it does in ordinary tap water, in many types of waters soap efficiency has been increased 50%" (*4*). Another bulletin (*6*) states that "39.8%

more soap was required to form initial suds in raw water." In another bulletin (*7*) the claim is made: "If the hardness of the raw water is less than 10 grains, Evis treatment alone saves enough soap through increased efficiency to justify bypassing the softener. Over 10 grains, the softener should be kept in service but used only for the wash operation. (For domestic use the advantages and economy of Evis far outweighs a softener in any hardness of water.)"

*Laboratory studies.* Such claims as stated above can be analyzed for their validity by the standard soap titration test (*10*). This is a practical test as well as one which gives accurate and highly reproducible results. Sufficient soap solution is added to the water samples to precipitate all of the hardness-producing cations, and a slight excess, the lather factor, permits the formation of a stable foam upon shaking. The foam must be stable for a period of 5 min. Figure 6 compares the effects of Evis treatment and of no such treatment of Cambridge tap water on the formation of soap suds which remain stable for a specified interval of time. As can be seen from the two curves, the same number of milliliters of standard soap solution was required for the formation of suds in untreated waters as in Evis-treated waters. These results indicate that there was no soap saving which could be attributed to the use of the Evis Conditioner.

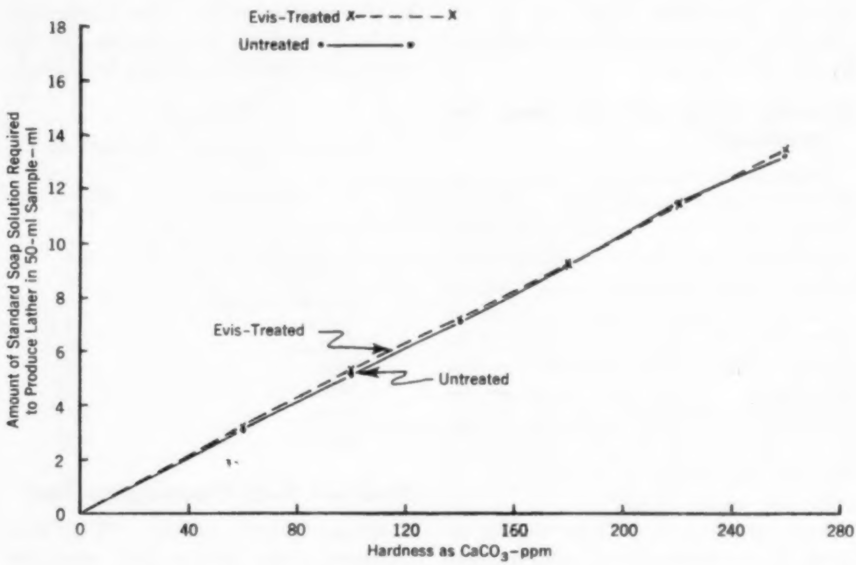


**Fig. 6. Effect of Evis Treatment on Soap Consumption**

*Cambridge tap water with hardness added was used.*

During these studies the waters were also tested for differences in sensations claimed to be experienced by rubbing the skin. The authors observed no dif-

ference in "feeling," such as "smoothness" or "texture," between the raw and Evis-treated waters.

## Laundering Efficiencies

*Manufacturer's claims.* "For fluffier, whiter, cleaner clothes Evis water is better for your laundry" (*4*). After a test on laundry wash water the manufacturer made the claim (*6*) that: "Before the wash water was drained at the end of the wash cycle another test was run. There was a consistently higher pH in Evis water which indicates that the soap had lost less of its power and that the soap curds were not in clothes where additional time and water would be required to rinse them out."

*Laboratory studies.* Cotton cloths were laundered in controlled tests using Cambridge tap water and various amounts of the household laundry detergent previously discussed. pH measurements were carefully made before and after washing uniform weights of cloth to show the effect of "conditioning" on the pH change in laundry waters, if any. The pH measurements at the end of the washing cycle, Fig. 7, can be compared with Fig. 5, which shows the pH before the washing action began. There was no significant change in the pH during the washing cycle. At the end of the cycle, the pH values of the Evis-treated waters were identical with those of the untreated waters within the limits of laboratory measurements. If pH changes show loss of power, as previously quoted from the manufacturer's claims (*6*),

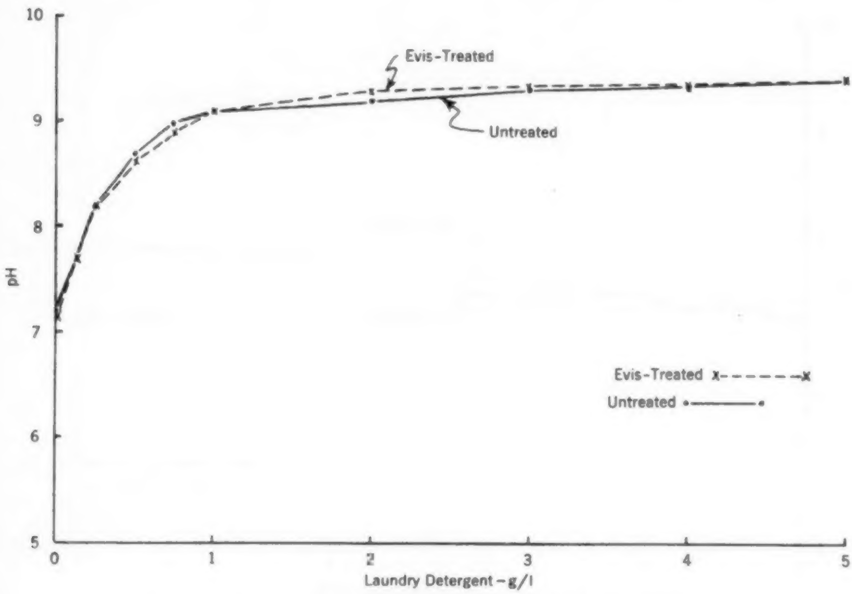


**Fig. 7. Effect of Evis Treatment on pH of Laundry Effluent**

*Laundry detergent was added to Cambridge tap water. Washing time was 20 min.*

then it can be concluded that there was no difference in "loss of power" during the laundry cycle when the water was passed through the Evis Conditioner.

The soap suds looked exactly the same in raw and "conditioned" waters in which similar amounts of soap were used. There was no observed difference in fluffiness or cleanliness between the cloths in raw and "conditioned" waters after washing.

## Laundry Rinsing Action and Water Consumption

*Manufacturer's claims.* "Cold hard (any hardness) Evis Conditioned Water is highly suitable for rinsing, and will not only save heat and softening, but also at least one rinse water. Evis rinses stop caustic carryover, which means that less soap and more alkalies can be used. Scouring acid may be cut in half, and starch will take hold" (*7*). Laboratory studies described in one bulletin, quoted previously (*6*), led to the following claim:

> A significant point in the laboratory report regarding the first rinse is that the pH raised ten times out of ten with raw water and only seven times out of ten with Evis water. This would indicate that the alkali had been largely drained away with the wash water instead of adhering to the clothes.
>
> A second rinse was needed ten times out of ten with raw water, and in every case the pH raised about three points. With the Evis water there was a pH rise in only two runs during the second rinse which is further proof that Evis-treated

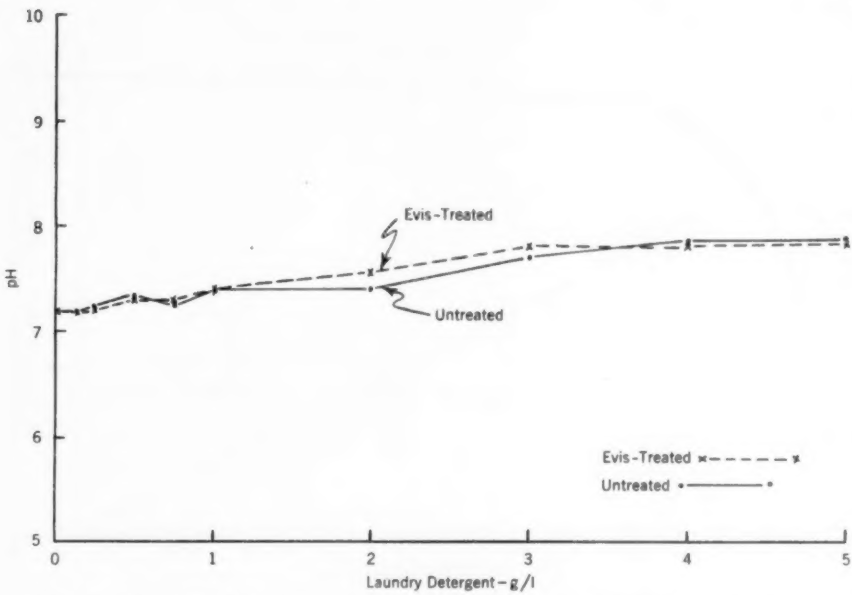


**Fig. 8. Effect of Evis Treatment on pH of Laundry Rinse Water—First Rinse**

*Cambridge tap water was used. Rinsing time was 10 min.*

water has a better rinsing ability. On the third rinse the raw water washes continued to show a pH rise in nine out of ten runs, but with Evis treatment there was nothing left to rinse out in eight of the runs, so the third rinse was run on only two runs and one of these failed to show a rise in pH. A fourth, and perhaps a fifth, rinse would have been required in nine out of ten raw water runs to completely rinse out the alkali. Raw water required 66⅔% more [rinses] than Evis water.

The same bulletin (*6*) quotes a testimonial from the Sudsy Duds Washateria in Lubbock, Tex., as follows: "It makes fine suds with any soap and the rinsing quality of the Evis conditioned water is far superior."

*Laboratory studies.* Water shortages and forced curtailment of water use are tremendously important in the water works news these days, and any method which may save water should be thoroughly studied. The claims of water savings made above were based upon pH changes in laundry rinse waters. Therefore, pH determinations were made on rinse waters from washes containing various amounts of laundry detergent, using both untreated and "conditioned" Cambridge tap waters. As can be seen from Fig. 8, the pH was greatly reduced in the first rinse in both raw and Evis-treated waters. Contrary to the manufacturer's claims, however, the pH was not higher in the untreated waters. The difference between the two waters was negligible and well within the limits of experimental error.

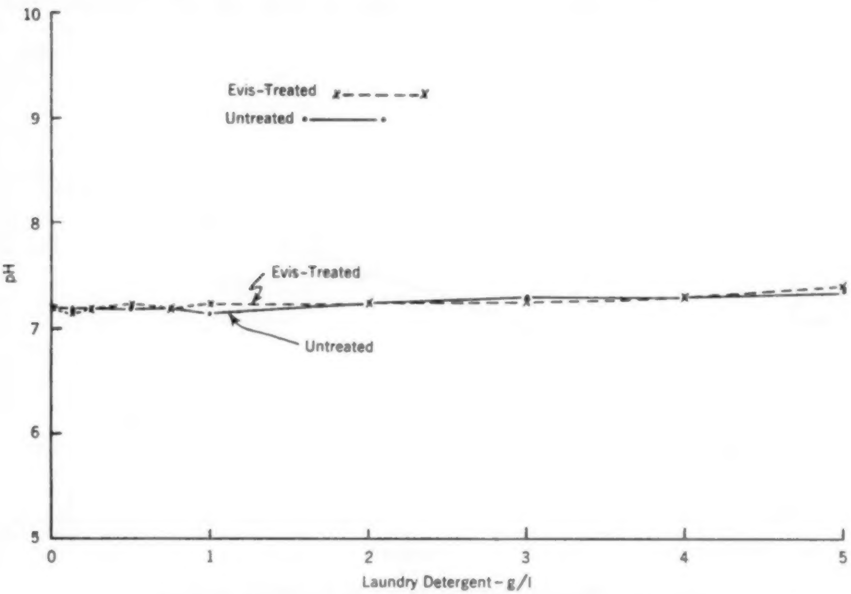


**Fig. 9. Effect of Evis Treatment on pH of Laundry Rinse Water—Second Rinse**

*Cambridge tap water was used. Rinsing time was 10 min.*

The second rinse, Fig. 9, showed that nearly all the alkali solution had been rinsed out of the cloths in both the untreated and Evis-treated waters. There was no significant pH difference in the second rinse due to the Evis Conditioner. The third rinse showed no change in pH in either the untreated or Evis-treated waters, indicating that a third rinse would not have been necessary in these tests using either water.

It can be concluded from these studies that there was no observed difference in rinse water effects due to Evis-treatment of water. From these tests there appears to be no basis for the claim that the Evis Conditioner saves on water consumption in laundry and cleaning operations.

## Scale Control

*Manufacturer's claims.* "In Evis Processed Water, scale is prevented. Old scale washes out as Evis Processed Water extracts salts out of the old scale structure" (*8*). One bulletin (*3*) claims: "The Evis catalytically endows water with new colloidal properties. This change increases the scattering and dispersing effect upon fine particles of matter which may be contained in the water including fine particles added to the water, and also upon matter that takes form in the water, such as encrusting particles." The same bulletin (*3*) states: "Scale is recognized as a porous sedimentary deposit—and when Evis-ized water is introduced to old scale it becomes pentrated. This penetration (not accom-

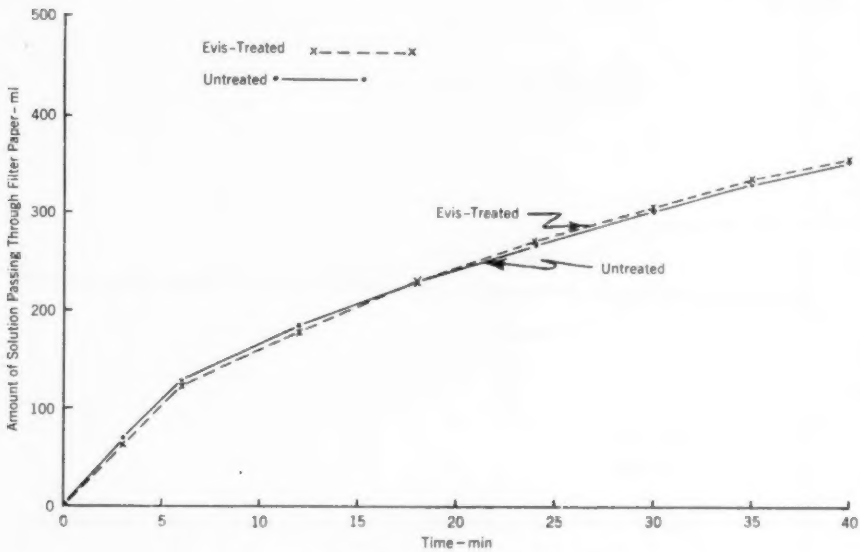


**Fig. 10. Effect of Evis Treatment on Solubility of Scale**

*One liter of distilled water with 11.85 g of scale added was used.*

plished by raw water) causes the scale to swell, slough off, and become washable."

*Laboratory studies.* Tests were designed to determine the behavior of Evis-treated water in contact with scale. The scale was placed in contact with both untreated and Evis-treated waters. Rates of solution of the scale were measured by the total hardness content of the water in contact with the scale. Figure 10 shows the results of these tests. They indicate that the rate of scale solution was the same in both the untreated and Evis-treated waters. Thus, it would appear that the Evis Conditioner had no effect in changing the behavior of water with respect to the removal of scale from surfaces in contact with water.

## Calcium Carbonate Structure Related to Precipitation and Scaling

*Manufacturer's claims.* "The water which passes through the Evis Process Unit becomes affected in some of its physical behavior. Evis Processed water provides salt-free precipitated mineral matter, and scale is prevented because the flocs are not adherent. Such flocs are sufficiently dense to gravitate to lower levels. With unprocessed water, lime particles join to form groups or 'flocs.' These flocs contain water films, are jelly-like, and tend to be adhesive to metals. With Evis processed water lime particles join to form tighter flocs or granules. The heavy flocs act like small grains of sand, which do not form scale" (*9*).

*Laboratory studies.* The significance of any theory must be evaluated by per-

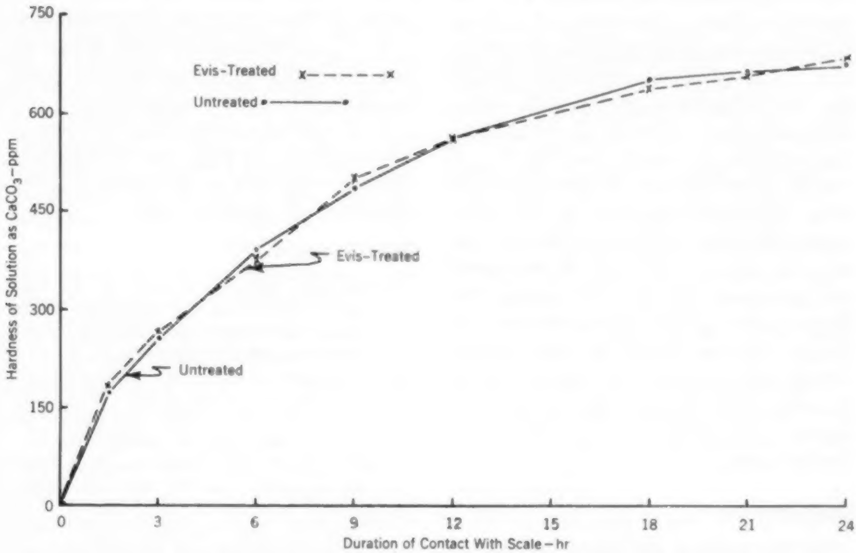


**Fig. 11. Effect of Evis Treatment on Filtration of Calcium Carbonate Solution**

*Distilled water with calcium carbonate ($CaCO_3$) added was used.*

formance tests. A clue to the flocculent or granular structure of precipitates can readily be obtained by measuring the filtration characteristics of lime precipitates formed in Evis-treated and untreated waters. Adherent flocs would filter much more slowly than the "granules . . . like small grains of sand" referred to in the above quotation (*9*).

Solutions of calcium carbonate were made up with Evis-treated and untreated waters. An excess of calcium carbonate was added to cause precipitation. The solutions were then filtered and the volumes of filtrate were measured with time. Results of these filtration studies are shown in Fig. 11. It may be observed that the density of calcium carbonate buildup on the filter paper resulting in loss of filter action was the same with both Evis-treated and untreated waters. It follows that the granular nature of the calcium carbonate was the same in both waters. These tests indicate that there was no physical difference in the calcium carbonate precipitate due to the Evis Conditioner.

## Conclusions

On the basis of the foregoing laboratory studies on the *behavior* of water "conditioned" by the Evis Water Conditioner, the following conclusions may be drawn:

1. The *behavior* of the water was not changed with respect to the complexing of calcium or magnesium by EDTA.

2. "Conditioning" did not affect the pH values of water used for laundering, either before or after the washing cycle.

3. During laundering operations the amount of soap required to produce stable suds was not affected by "conditioning" in the Evis unit.

4. The *Standard Methods* soap hardness test was not affected by this type of "conditioning" of waters of various degrees of hardness.

5. "Conditioning" did not affect the pH of rinse waters, and therefore no saving of rinse water was accomplished.

6. "Conditioning" did not affect the rate of solution of substances commonly found in hard-water scales.

7. No effects were noted in some of the pertinent physical characteristics of calcium carbonate as the result of "conditioning" in the Evis unit.

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# Factors to Be Considered in House Piping Sizes and Selection of Meters

C. M. Mathews

*A paper presented on Oct. 24, 1956, at the Alabama-Mississippi Section Meeting, Mobile, Ala., by C. M. Mathews, Asst. Supt., Public Service Com., Yazoo City, Miss.*

To the average person, the size of a meter and the size of a service are synonymous. Ignorant of the amount of water he may use in a month, he prefers to allow the water department to judge the necessary meter size. The water department, as a rule, can inform him of the smallest meter available or, in case of doubt, can advise him to install an oversize meter. An oversize meter is no solution, however, for it creates an unnecessary expense to the customer and decreases the water department's revenue by underregistering consumption.

Considerable study has been made on service sizing; meter sizing is a phase of this. A study applicable to the country as a whole is usually based on averages, so that care must be taken in using results for actual installation.

## Fixture Demand

An ample supply of water at an adequate pressure is dependent on several things: [1] the fixture (or fixtures) being used; [2] the pressure at the main; [3] the elevation of the fixture; and [4] the length and size of service line. The results of one of the most widely accepted studies (*1*) on rate of flow and pressure requirements are shown in Table 1.

A satisfactory water system may be designed using Table 1 as a guide, by assigning similar values for fixtures comparable to those shown in the table. The system probably would have a far larger capacity than is necessary and be very expensive, as it would be designed for all fixtures being open at the same time—which is very unlikely.

The more fixtures there are on a line, the less likelihood is there of all of them being in use simultaneously. No one has the facilities or the time to correlate the amounts of water used by the different fixtures, the time at which valve is likely to be open, the likelihood of any number of units being in operation at any one time, and the likelihood of a time-overlap for use of these fixtures.

Flow quantity, time of operation, and frequency of use, expressed as fixture units, were used in a study (*1*) to calculate the most probable demands made upon certain fixtures. The results of this study, shown in Table 2, have proved to be accurate and reliable under field conditions, even though slight drops in pressure and quantity of water for a few minutes each day might be evidenced.

In order to calculate the demand in gallons per minute made upon a service, the total number of fixture units should be added from the figures given in Table 2 and then read off on the chart shown as Fig. 1. As the esti-

TABLE 1

*Rate of Flow and Pressure for Plumbing Fixtures*

| Fixture | Flow Pressure* *psi* | Flow Rate *gpm* |
|---|---|---|
| Ordinary basin faucet | 8 | 3.0 |
| Self-closing basin faucet | 12 | 2.5 |
| Sink faucet (3/8 in.) | 10 | 4.5 |
| Sink faucet (1/2 in.) | 5 | 4.5 |
| Bathtub faucet | 5 | 6.0 |
| Laundry tub cock (1/2 in.) | 5 | 5.0 |
| Shower | 12 | 5.0 |
| Ball cock for closet | 15 | 3.0 |
| Flush valve for closet† | 10–20 | 15.0–40.0‡ |
| Flush valve for urinal† | 15 | 15.0 |
| Garden hose (50 ft) and sill cock | 30 | 5.0 |

* Flow pressure is the pressure in the pipe at the entrance to the particular valve considered.

† A pressure of 15 psi is usually ample for flush valves. A minimum of 8 psi should be allowed for other fixtures.

‡ Wide range due to variation in design and type of flush valve closets.

mates are for intermittent use only, figures for continuous water demand, such as that from air conditioners and garden hoses, should be added to the total likely demand. The estimated demands for garden hoses and sill cocks are given in Table 3.

Having calculated the total demand, the size of the service may be chosen. If main pressure is no problem, meters may be installed by using as a guide the AWWA recommended procedure for testing cold-water meters (*2*).

When the pressure drop from the main to the fixture is limited, the daily minimum pressure in the main and the approximate difference in elevation between the main and the highest fixture must be known. If this difference in elevation is multiplied by 0.43, the result will be the pressure drop due to elevation, expressed in pounds per square inch. If the sum of the flow pressure (Table 1) and the pressure loss due to elevation is subtracted from the minimum main pressure, the result is the pressure drop that may be used in overcoming the resistance of water to the pipe and internal resistance of the water.

In a service tied to a main with a 50-psi minimum pressure, if the highest fixture is a water closet at 10 ft above the main and a flow pressure of 10 psi is chosen, the pressure drop will be 10 ft × 0.43, or 4.3 psi. Subtracting these from the main pressure gives:

$$50.0 \text{ psi} - (10 \text{ psi} + 4.3 \text{ psi}) = 35.7 \text{ psi}$$

TABLE 2

*Demand Weight of Fixtures**

| Fixture† | Type of Supply Control | Weight in Fixture Units‡ |
|---|---|---|
| Water closet§ | flush valve | 10 |
| Water closet§ | flush tank | 5 |
| Pedestal urinal§ | flush valve | 10 |
| Stall or wall urinal§ | flush valve | 5 |
| Stall or wall urinal§ | flush tank | 3 |
| Lavatory§ | faucet | 2 |
| Bathtub§ | faucet | 4 |
| Shower head§ | mixing valve | 4 |
| Service sink‖ | faucet | 3 |
| Kitchen sink‖ | faucet | 4 |
| Water closet# | flush valve | 6 |
| Water closet# | flush tank | 3 |
| Lavatory# | faucet | 1 |
| Bathtub# | faucet | 2 |
| Shower head# | mixing valve | 2 |
| Bathroom group# | flush valve for closet | 8 |
| Bathroom group# | flush tank for closet | 6 |
| Separate shower# | mixing valve | 2 |
| Kitchen sink# | faucet | 2 |
| Laundry trays (1–3)# | faucet | 3 |

* For supply outlets likely to impose continuous demands, estimate continuous supply separately and add to total demand for fixtures.

† For fixtures not listed, weights may be assumed by comparing the fixture to a listed one using water in similar quantities and at similar rates.

‡ The given weights are for total demand. For fixtures with both hot and cold water supplies, the weights for maximum separate demands may be taken as three-fourths the listed demand for supply.

§ Public occupancy.

‖ Office, hotel, or restaurant.

\# Private occupancy.

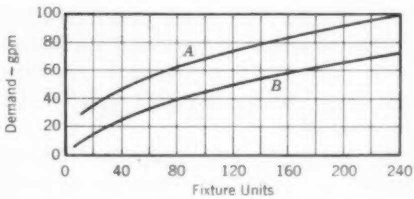


**Fig. 1. Demand Weights in Fixture Units**

*Curve* A *applies to systems designed predominantly for flush valves; curve* B *applies to flush tank systems.*

## Example

A building with two bathrooms, one kitchen sink, and one laundry tray, with flush tanks, for example, has a total of seventeen fixture units for a demand of 12 gpm. The building also has two sill cocks, for which the demand is 9 gpm. The total demand is thus 12 plus 9, or 21 gpm. To meter this rate, a $\frac{3}{4}$-in. unit or any other larger meter might be used. If there is little likelihood of both sill cocks being used at the same time, a $\frac{1}{2}$-in. meter might be substituted.*

TABLE 3

*Water Demands for Garden Hose and Sill Cock*

| Number of Outlets | Estimated Demand—*gpm* |
|---|---|
| 1 | 5 |
| 2 | 9 |
| 3 | 12 |
| 4 | 14 |
| 5 or more | 3 per outlet |

* The use of a number of fixture units as a measure of demand, as outlined by the author, will encourage the installation of adequate piping, but is not to be interpreted as a suggestion to install meters with the simultaneous capacity that might be considered to be required by the situation. As the author points out in the first paragraph, an oversize meter is no solution, since it is expensive and tends to underregister consumption.—*Ed.*

The flow pressure is 30 psi at the sill cock (el 3) at the back of the house. This then becomes the controlling factor, rather than the highest fixture, as is normal. If the main pressure is 50 psi, then: 50 psi − (30 psi flow pressure + [3 × 0.43 psi elevation drop] = 18.7 psi drop for overcoming pipe friction.

Pressure losses in the meter, given in Fig. 2, must also be included in the calculations. At 21 gpm, the loss in a $\frac{3}{4}$-in. meter is approximately 9.3 psi; for a 1-in. meter, 3.8 psi; and for a $1\frac{1}{2}$-in. meter, 1.1 psi.

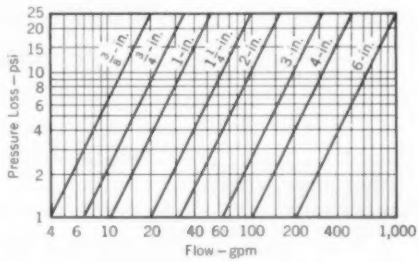


**Fig. 2. Pressure Losses in Water Meters**

*The curves refer to designated meter sizes.*

If the pipe is to be 1-in. of galvanized iron, a 21-gpm flow through it will have have a pressure drop of 20 psi per 100 ft at a velocity of 8.5 fps. For purposes of estimating, it is usually accurate enough with iron pipe to add an equivalent of 12–15 ft of pipe for losses caused by the corporation stop, curb stop, and meter couplings. Exact losses may be found in manufacturer's catalogs or technical data. In the first 3-ft run from the corporation to the front sill cock, losses equivalent to 30 + 15, or 45 ft of pipe will be allowed. This gives $\frac{45}{100} \times 20$ psi, or 9 psi drop in the first 30 ft run.

In the next run of 20 ft, the 17-gpm flow, still through a 1-in. pipe, will suffer a pressure drop of 12.5 psi per 100 ft of pipe at a velocity of 6.5 fps. For 20 ft this would be a total drop of $\frac{20}{100} \times 12.5$, or 5 psi drop in this section.

The next run of 40 ft, still using 1-in. pipe, at a flow of 13 gpm, will have a drop of 7.5 psi per 100 ft at a velocity of 5.0 fps. For 40 ft this will be $\frac{40}{100} \times 7.5$, or 3.0 psi in this run. The total drop, then, is:

| Location | Pressure Drop *psi* |
|---|---|
| Meter | 3.8 |
| First 30-ft run | 9.0 |
| Second 20-ft run | 5.0 |
| Third 40-ft run | 3.0 |
| Overall drop | 20.8 |

## Conclusions

A 1-in. service may or may not be satisfactory in the above example, depending on: [1] whether both sill cocks were opened for long periods of time; [2] whether the short runs to the other fixtures were large enough so that both cocks being opened would not rob the other fixtures of water; and [3] whether the extra pressure drop (20.8 psi actual drop − 18.7 psi allowable drop = 2.1 psi excess pressure reduction) at the back sill cock will be objectionable.

If a smooth pipe (copper, lead, or brass) had been used, there would have been considerably less pressure loss.

Runs to the individual fixtures for either hot or cold water are determined in the same way as for the service line in the preceding problem.

It should be pointed out that, as the velocity of the water approaches 10 fps, there is a likelihood of unpleasant noises and water hammer.

Often a reduced pressure is blamed on too small a meter, but in view of the small pressure drop through the meter compared to the drop in the rest of the service line, the blame is misplaced.

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# Repairing a Water Main From the Inside

**_Maurice Brunstein and James S. Long_**

*A contribution to the Journal by Maurice Brunstein, Supt. & Engr., Water Dept., Atlantic City, N.J., and James S. Long, Chemical Director, Keeler & Long, Waterbury, Conn.*

THE pumping station of the Atlantic City Water Department, located in Pleasantville, N.J., has a capacity of 40 mgd (four motor-driven pumps) with 39-mgd standby (three gasoline engine–driven centrifugal pumps). The discharge pressure is 45–50 psi, depending on consumption requirements. The distribution system in the city is served by two 48-in. cast-iron transmission mains, each approximately 26,000 ft long. Both of these mains have submarine crossings, and one of them passes through the yards of the Pennsylvania Railroad.

In August 1956, a leak was discovered in the latter main at a point where the pipe is 14 ft below the tracks and not far from the submarine crossing. The leak had softened the ground to the extent that the trackage was springing up and down. The main could not be shut off for repairs, as this was a peak season for the resort city; therefore, a special drainage system was installed as a temporary expedient to remove the major part of the leakage. The railroad estimated that the cost of a project to sheet-pile and excavate to the pipe where repairs could be made, while still maintaining traffic with safety, would be $25,000–$30,000. This would have been a time-consuming and hazardous job, the expense of which would have been borne by the water department because of an existing agreement with the railroad. After considerable thought and planning, the department decided to have a crew enter the pipe and try to repair the leak or leaks from the inside.

### Preparations for Repairs

It was fortunate that the leak occurred in a well valved section (see Fig. 1) containing a standard bell and flange tee with a flanged opening that served as a manhole for entry. Valves A, B, and C were closed and two of the gates from Valve D—a 30-in. swing check valve—were removed to provide air circulation for the work crew and improve communication with it. The leak appeared to be about 50 ft from this valve, which was in a concrete and brick manhole.

Diaphragm pumps were used to dewater the line, but a small amount of seepage continued to come through the closed valves. When calking failed to prevent this, sandbags were placed above and below the valves and the pumps were kept running night and day during the course of the operation.

When the water was down to a few inches in depth, the repair crew entered the pipe and found that five joints were leaking. The trouble was due to the fact that, when the main was laid (in 1914), a curve had been made by

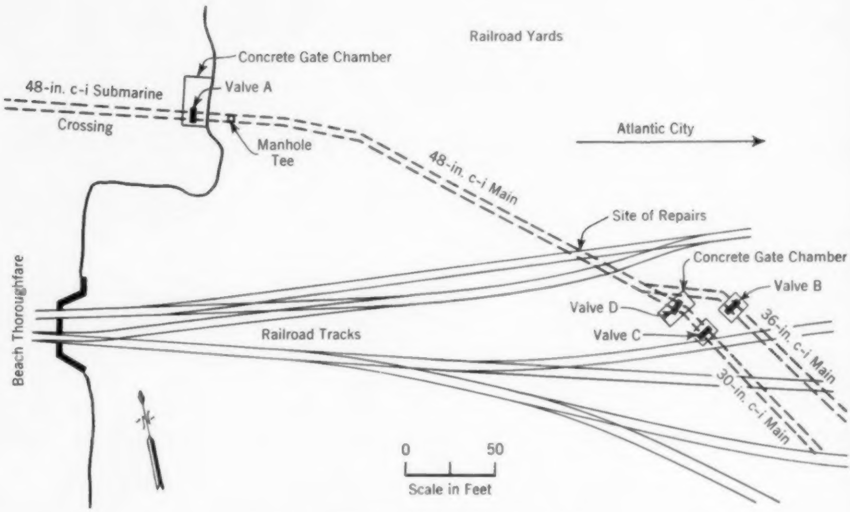


**Fig. 1. Sketch Map of Repair Site**

**Fig. 2. Repaired Main**

*This flash photograph was taken after the resin had been allowed to cure overnight.*

deflecting the pipe instead of using bends. At several joints the opening between the spigot and the bell on the outside edge of the curve was as much as 2 in.—considerably in excess of present AWWA standards. Apparently years of vibration from the trains running overhead had finally created enough movement to produce leaks, even though the pipe was supported on pile bents. Fortunately, there were no breaks in the pipe itself, although part of the spigot end of one section had been considerably worn away as a result of the velocity of the leakage.

TABLE 1

*Comparison of Epoxy Resins and Other Materials*

| Material | Molecular Weight | Force at Crumpling Point *dynes/cm* | Area at Crumpling Point *sq cm* $\times 10^{-16}$ | Force to Uproot | | Adhesion *psi* |
|---|---|---|---|---|---|---|
| | | | | 1 molecule *dynes* $\times 10^{-7}$ | 1 sq cm *dynes* | |
| Epoxy resin— | | | | | | |
| Epi-Rez* No.: | | | | | | |
| 540 | 2,900 | 7.9 | 56.9 | 5.83 | 10.25 | 1,491 |
| 530 | 1,400 | 7.8 | 30.0 | 4.16 | 13.85 | 2,010 |
| 522 | 791 | 7.7 | 12.8 | 2.75 | 21.5 | 3,120 |
| 510 | 361 | 7.6 | 1.4 | 0.90 | 64.1 | 9,260 |
| Tung oil | 778 | 10.2 | 155.0 | 6.95 | | 1,827 |
| Linseed oil | 868 | 9.2 | 44.4 | 6.12 | | 2,000 |

* A trade name of Jones-Dabney Division of Devoe & Raynolds Co., Louisville, Ky., applying to a series of epichlorohydrin bisphenol resins.

## Repair of Leaks

The crew started cleaning the inside of the pipe at the five joints which appeared defective. Tubercles and loose rust were thoroughly cleaned out of the joints, and the areas adjacent were scraped and wirebrushed. After inspection, it was decided to try to calk the joints with lead. Accordingly, lead dutchmen * were made, having a curvature approximately that of the pipe and about 24 in. long and $\frac{3}{8}$ in. thick. Four layers, staggered with approximately a 1-ft lap and carefully and thoroughly calked, were used. These constituted the main backing to stop the leaks, and they were probably responsible for checking 80–90 per cent of the water flow. It is, of course, difficult to get dutchmen to form a perfect seal, but they filled and closed most of the joint space to within $\frac{1}{4}$–$\frac{3}{8}$ in. of the interior surface of the pipe.

On the inside of the curve the amount of lead that could be introduced was small, as the pipe lengths were generally fitted tightly together there, whereas on the outside they were much farther apart. The thickness of the lead packing therefore varied from nothing to perhaps 2 in. in some spots. After the lead dutchmen were in place and well calked, a groove, $\frac{1}{8}$–3 in. wide which had been purposely left, was filled with epoxy resin.

* Special pieces to fill openings or strengthen weak parts.

## Epoxy Resin

Epoxy resin is not a new material; it has been much in use, especially as a molding resin, an adhesive, and a

coating film which is very resistant to water, strong alkalies, acids, and solvents. The resin has two principal features that led to its choice for the job in question: [1] it has great adhesion to metal or masonry; and [2] various members of the epoxy resin family can be selected which have either no contraction on curing or even a slight expansion to fill cracks or open spaces between the dutchmen. The resin is nontoxic, being used as a coating on the inside of many food cans. It sets or cures quickly, but still allows ample time (10–15 min) in which to work it.

The resin is cured (changed from a liquid to a hard but tough, strongly adhesive solid) by a polyamine "converter." The converter is stirred, in exact measured quantity, into the resin approximately 10–20 min before use, depending on temperature conditions. Within a few minutes the converter begins to act.* During the 10–15 min curing period, the resin must be wiped around in the joint with a trowel, a spatula, or a long-handled, stiff-bristle artist's brush. The resin overhead naturally tends to flow slowly downward in the groove, so that it is necessary to keep it in place until the mass has set to a solid. No special precaution is necessary to get perfectly smooth joints. A little resin can jut up above the surface of the pipe, as it is tough and adheres strongly.

## Further Repairs

After these repairs had been made, the swing gates were put back in the 30-in. check valve, and a bypass valve was opened to let the water reenter the main at 50 psi pressure. Although the leakage was greatly reduced, some water continued to come up out of the ground. To check this leakage, the main was again drained, opened, and dewatered. This time the men went in as quickly as possible, while approximately 10 in. of water remained in the line. A rubber-covered electric line with a string of 100-w bulbs was fastened to the top of the main by screwing hooks into the lead joints. Power was furnished by a gasoline engine–driven portable generator.

It was noticed that ground water from the outside was running into the pipe at the middle joint of the five previously repaired. Entering the pipe promptly made this observation possible, since otherwise the ground water

* The converter causes chemical cross linking between adjacent molecules in the plastic resin mass. A small quantity of pigment is present to raise the plasticity. The active hydrogen atoms of the polyamine converter unite chemically with the epoxy groups in the resin molecule, thus joining the individual molecule chains of the resin together and leading shortly to the formation of such large molecules that their mobility becomes very low and the resin sets to a solid.

The free velocity of motion of a material in the liquid state is governed by the familiar equation:

$$\text{Kinetic energy} = \frac{1}{2}MV^2$$

in which $M$ is the mass of the molecule and V is its velocity. Doubling $M$ lowers $V$ to one-fourth, so that the linkage of resin molecules by the polyamine hydrogen causes them to slow down and the resin to solidify. As the reaction is exothermic, the temperature of the resin mass rises. The speed of reaction likewise increases sharply, in a more or less parabolic curve.

Table 1, taken from a study by Long and Yuan (*1*), compares the adhesion of this type of resin with that of other materials. The adhesion of epoxy resins to iron, steel, or hydrophilic (water-loving) surfaces was greater than that of the other materials studied. For this reason, an epoxy resin was chosen for the final seal in the grooves over the lead dutchmen previously described. The actual resin selected was Epi-Rez No. 510 (see Table 1).

would have run into the pipe and been pumped out. It was encouraging to find that the other joints were holding tight.

All the epoxy resin and lead were removed from the middle joint, and it and the adjacent area were then sand blasted thoroughly in order to get down to clean metal. New dutchmen were made of soft virgin lead, enabling them to be more readily calked. It was important for the surface to be completely dried to get good adhesion of the resin. Infrared lamps were focused on the crack as a final measure to evaporate any moisture left in the groove. Although the pipe carried the heat away too rapidly to produce any real rise in temperature, the moisture did evaporate and the surfaces of the groove were absolutely dry when the resin mixed with converter was applied. The resin was allowed to cure overnight. (Figure 2 is a photograph taken the following day.) The manhole plate was then put back in place, and the main was thoroughly flushed and chlorinated.

The repaired main has been in operation since September 1956. As there has been no observable leakage or seepage and no wet spots under the railroad tracks, it is felt that the lead–epoxy resin method has been effective. The cost of the job was minor compared with the cost of repair by more conventional methods. The successful completion of the job was due in large part to the conscientious endeavor and workmanship of the repair crew, with Walter E. Hackett in charge; the other crew members were Dominic Phillips, Steve Horvath, James Clark, Joseph Harbright, and Frank Whittington.

## Reference

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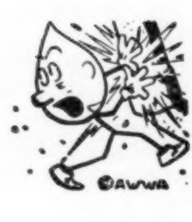

# Maintaining Pipeline Flow Capacity After Cleaning

**William D. Monie and Harold B. Scales**

*A paper presented on Oct. 19, 1956, at the New Jersey Section Meeting, Atlantic City, N.J., by William D. Monie, Chief Engr., and Harold B. Scales, Chemist, both of the Portland Water Dist., Portland, Me.*

IN June 1955, a 14-month study was begun in Gorham, Me., on the maintenance of pipeline coefficients after cleaning with sodium hexametaphosphate.

Gorham Village is one of the areas supplied by the Portland Water District. Because a large percentage of Gorham Village is above the gradient of Sebago Lake, the source of supply, a booster pump is needed to deliver water to the system. The booster pump is located at one end of the system, and a standpipe located at the opposite end floats on the system. The distance between the booster station and the standpipe is approximately 11,000 ft. The main feed from the booster station to the standpipe consists of an 8-in. pipeline with a small grid in the center of the system. A diagram of the system is shown in Fig. 1.

The pumping facilities of the booster station consist of an electrically driven centrifugal pump with a capacity of 420 gpm, together with a centrifugal pump operated by a gasoline engine for use as a standby in case of power failure. The electrically driven pump, installed in 1918, had dropped in efficiency. The district was, therefore, interested in replacing this unit with a modern, more efficient pump.

In investigating to obtain the information necessary to design a proper pump for this location, it was found that the coefficient $C$ for the 8-in. line between the booster station and the standpipe varied from 50 to 56. Before proceeding it was felt that some action should be taken to reduce the head against which the pump would operate.

Further study revealed that this 8-in. main between the booster station and the standpipe had been cleaned 20 years before. This fact proves again that it is not advisable to clean a water main without retarding corrosion either by chemical treatment or lining. To replace this pipeline or adequately reinforce the system would have been expensive. As Gorham Village is a small, isolated portion of the Portland Water District's system, it was felt that it would make an ideal system for studying the effect of chemical treatment after pipe cleaning. It was decided to clean a portion of the 8-in. main and to make a careful study for a year to determine the effect of chemical treatment on the pipe coefficient. If this experience disclosed that corrosion could be retarded sufficiently without any ill effects, then all of the 8-in. pipe from the booster station to the standpipe, together with some of the

6-in. grid was to be cleaned. Ordering of a pump replacement was postponed until the end of the study so that the pump design would be proper for the cleaned condition of the main.

After study, sodium hexametaphosphate * was selected because of its ease of application and apparent success in other locations. It was also felt that this treatment was more appropriate to automatic station operation. If the treatment proved unsuccessful, lime or a combination of lime and metaphosphate was to be tried.

## Preparation and Cleaning

For one month prior to cleaning, metaphosphate was added at a rate of approximately 4 ppm. This was done in the hope that it might soften some of the tubercles, and that its dispersing effect might aid in removal of the scale deposit.

* The sodium hexametaphosphate used in the study was Calgon brand, a product of Calgon Company Division, Hagan Chemicals & Controls, Inc., Pittsburgh, Pa.

On Jun. 21, 1955, a 4,000-ft section of the 8-in. main on the discharge side of the booster pump was cleaned with a conventional pipe scraper. It was believed that this section was one in which it would be most difficult to maintain a high pipeline coefficient because the pump operates an average of 5–6 hr per day, with a condition similar to a dead end prevailing for the remainder. Figure 2 shows the scraper in position to enter a section of pipe which was later sleeved into the main at the point where the cleaning operation was to start.

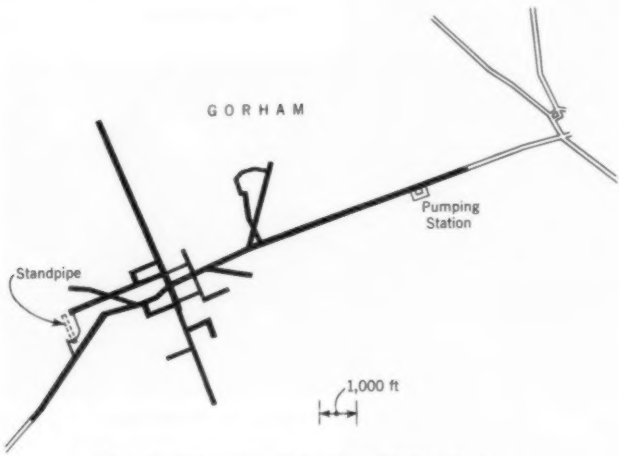


**Fig. 1. Diagram of Gorham Water System**

In the cleaning operation enough pressure was maintained behind the scraper to make it travel no faster than a very slow walk. Before starting the scraper, all the hydrants on the section of the main to be cleaned were opened, and all services and grid connections were shut off. At each hydrant, the scraper's travel was stopped by the drop in pressure as water was released at the hydrant. The hydrant was left open until the water flowed fairly

clean; the hydrant was then closed and the scraper allowed to travel to the next hydrant, and so on until the scraper emerged from the open end of the section being cleaned (Fig. 3).

In each cleaning the scraper was run through the entire section twice. Before the second run, 0.5 lb of zinc-bearing phosphate glass * for each 1,000 ft of pipe was placed behind the cleaner. After the second cleaning, the pipe was flushed and put back in service.

glass. This treatment was continued for approximately 2 weeks after cleaning, when the zinc-bearing phosphate glass was eliminated. Metaphosphate was fed for an additional 2 weeks at the rate of 9 ppm, after which it was decreased to 5.5 ppm.

The zinc-bearing phosphate glass lays a coating more quickly than regular metaphosphate. The authors feel that it is of the utmost importance that this composition be used immediately after cleaning.

**Fig. 2. Scraper in Position to Enter Pipe**

## Application of Metaphosphate

The metaphosphate was applied by means of a heavy-duty diaphragm pump feeder.† The pumping station delivery rate was approximately constant and, therefore, proper dosage was easily obtained without the necessity of proportional feed. The initial rate of feed was 7 ppm of metaphosphate and 6 ppm of zinc-bearing phosphate

* Calgon, Composition TG, also a product of Calgon Company Division, previously mentioned.

† Feeder used was a Chem-O-Feeder, manufactured by Proportioneers, Inc., division of B-I-F Industries, Providence, R.I.

## Calcium Level

Table 1 shows a typical analysis of the Portland Water District's water supply as collected in the laboratory. It will be noted from this that Sebago Lake water is very soft, with a pH of 6.7 and a low total solids content. The calcium content is 4.5 ppm and the iron content only a trace.

In using sodium hexametaphosphate it is necessary that the water supply to be treated have a minimum calcium content of 1 ppm for each 4 ppm of metaphosphate added. This amount of calcium is necessary to combine with the metaphosphate to form the compli-

cated chemical complex which protects the pipe. If more than 4 ppm of metaphosphate is added for each part of calcium in the water, the metaphosphate itself would become corrosive. If there is insufficient calcium present for the initial high treatment necessary, it can be added in the form of calcium chloride or lime.

## Effects of Cleaning

Figure 4 shows the coefficient obtained on the 4,000 ft of cleaned main over a period of approximately 14

TABLE 1

*Chemical Analysis of Gorham Water Supply*

| Item | Amount *ppm* | Item | Amount *ppm* |
|---|---|---|---|
| Chlorides | 2.4 | Silica | 6.0 |
| Nitrates | 0.05 | Aluminum | trace |
| Nitrites | trace | Sodium | 1.7 |
| Ammonia (free) | 0.028 | Potassium | 1.6 |
| Ammonia | | Calcium | 4.5 |
| (albuminoid) | 0.074 | Magnesium | 1.0 |
| Dissolved | | | |
| Oxygen | 11.1 | Manganese | — |
| Hardness | 14.0 | Sulfates | 6.0 |
| Alkalinity | 5.4 | Carbonates | 6.0 |
| Carbon dioxide | 1.0 | Fluorides | — |
| Iron | trace | pH | 6.7 |
| Total solids | 27.0 | | |

months. It will be noted that the *C* value immediately after cleaning was 130. It was felt that this coefficient was unreasonably high, but a check of the meter, gages, elevations, and calculations disclosed the coefficient to be correct. Tests taken 2 months and 4 months after cleaning showed that the coefficient was increased to 132.5 on Oct. 20, 1955. These results were extremely unreasonable. It was fairly obvious that there was either leakage or consumption between the two points that were used to determine the coefficient. Samples were taken for iron determination at intervals along the 4,000-ft section of cleaned main, and a decided drop was found in the iron content at a point approximately midway in the clean section of pipe. A leak survey of this section of main disclosed a joint leak where the pipe lies approximately 11 ft deep in a filled portion of a road. After the leak was repaired, the coefficient dropped to a value between 121 and 122. This was a rea-

**Fig. 3. Scraper Emerging From Cleaned Section**

sonable coefficient and has been maintained to date. The tests to determine the coefficient was made at 2 AM to eliminate as much excessive usage between test points as possible. Some fluctuation in the computed *C* value is to be expected because of the short test section. A difference of 0.25 psi in a gage reading will make a few points difference. On each date shown in Table 1, two tests were made and the

results averaged. The average results are shown in this figure. It is well to note that the coefficient of this test section prior to cleaning was 56.

Figure 5 is a composite of three separate flow charts, one showing the pumping rate prior to cleaning the test section of the main, one 3 weeks after cleaning, and the third 13 months after cleaning. It will be noted that the pumping rate before cleaning was approximately 600,000 gpd; immediately after cleaning, approximately 700,000 gpd; and, after 13 months, still 700,000 gpd, showing that the coefficient of the test section of cleaned pipe has been maintained.

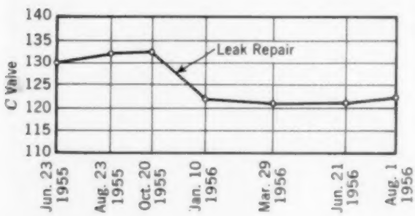


**Fig. 4. Pipeline Coefficient *C* After Cleaning**

*Before cleaning, C value was 56*

## Iron Pickup

To check the effectiveness of the metaphosphate treatment in addition to the coefficient test above described, it was felt that it was essential to keep a close watch on the iron pickup and the metaphosphate residual. The pickup of iron would be an indication of the protection afforded the pipe by the addition of sodium metaphosphate. If a complete protective coating were laid down on the pipe there would be no pickup in the clean section of main.

As previously stated, the pump normally operates from 9 AM to 2 PM and for the intervening 19 hr the village is supplied from the standpipe. Samples were collected for iron determination from three points: one at each end of the cleaned section, 4,000 ft apart, and one near the standpipe, 7,000 ft away from the cleaned section of pipe. The samples were collected just before starting the pump.

Figure 6 shows in the upper graph the metaphosphate feed in parts per million from Jul. 1, 1955, to the middle of August 1956. The lower graph shows the average iron pickup per hour in parts per million in the sample collected nearest to the pumping station. As is shown in Table 2, the iron content in the sample increases the longer the water remains in contact with the pipe in this dead-end section. Therefore, to obtain the amount of iron shown in Fig. 6, the iron content of the sample was divided by the number of hours between the time the pump was shut off and the time the sample was taken. Note the high initial rate of metaphosphate, as previously stated, which was then reduced to 5–6 ppm until February 1956. The reason for continuing the relatively high metaphosphate feed (in excess of 5 ppm) was to hold in solution the iron pickup that prevailed at that time, and thereby prevent oxidation of the iron and consequent red water complaints. It should be noted that the iron pickup was high from July to early November. It was anticipated that iron levels would be high immediately after cleaning, due, possibly, to corrosive products in the pipe which were not removed in the flushing process. As noted in Fig. 6, however, periodic flushings made only temporary improvements in the iron pickup. The lower iron content which persisted for practically all of September was due to a leaky check valve on the pump discharge. When

this was corrected, the iron content returned to its previous level.

After repairing the check valve it was decided to add lime in addition to metaphosphate to see if providing additional calcium to react with the metaphosphate would be of any benefit. It was felt that the addition of lime, with an increase in pH, would also decrease corrosion and that considerable corrosion reduction might be secured by increasing the pH to about 9.5—just beyond the saturation point. Addition of lime as the prime corrosion inhibitor was to be avoided, if possible, because of the difficulty of achieving a uniform lime feed in an unattended station. Only a slight reduction in Ion was experienced. Lime was fed during October only.

After noting the reduction in iron content in September (while the check valve was leaking) it was decided to install a 1-in. bypass around the check valve on the discharge side of the pump. While operating the bypass—in order to maintain a constant flow of approximately 30 gpm after the pump was shut off—there was a drop in iron pickup. It is felt that this reduction in iron content arose from the fact that the water was not in contact with the iron as long as previously and additional protective film was deposited because of the velocity increase. When the bypass was closed, the iron content increased, but did not, for the remainder of the test period, approach the iron pickup of the early months.

The increase in iron pickup since May 1, 1956 was probably due to the higher water temperature, although the decrease in late July and early August was probably due to a decrease in water

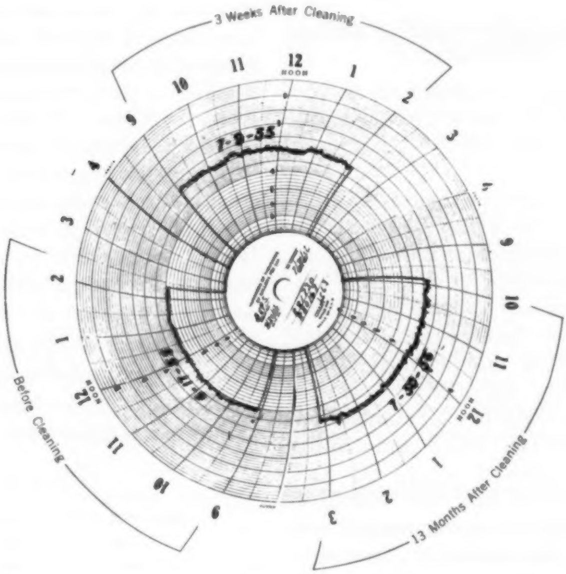


**Fig. 5. Composite Flow Chart**

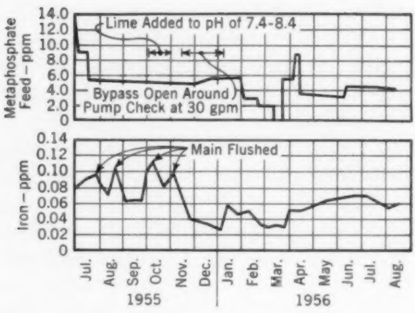


**Fig. 6. Metaphosphate Feed and Average Iron Pickup**

*Iron pickup was claculated from samples collected at point nearest pumping station—pump not running.*

temperature caused by the cool weather at that time. In Table 2, the pH on Oct. 24–25 reflects the addition of lime during that month.

Figure 7 shows the metaphosphate feed and iron determination for the period from the middle of February to the middle of April 1956.

During the middle of February the metaphosphate feed was 3 ppm and the iron determination 1 ppm. On Feb. 20 metaphosphate feed was reduced to 2 ppm and kept at this rate until March 12. During this period the iron content of the sample collected just before starting the pump (after the water was in the main for approximately 19 hr) deceased to 0.6 ppm. For the following 10 days no metaphosphate was added, and the iron level remained at 0.6 ppm. It was felt that the decrease in the iron content from 1 to 0.6 ppm was caused by the fact that the 2 ppm of metaphosphate was not sufficient to hold in solution all of the iron coming from the main, and, as a result, a portion of this iron was oxidizing and precipitating in the main. It is believed that the iron content remained at 0.6 ppm during the 10-day period when no metaphosphate was added because of the coating already on the pipe. Apparently, it is possible to discontinue metaphosphate feed for short periods without losing all the benefit of the treatment. The experiment was not continued without treatment to avoid buildup of scale or tubercles in the pipeline.

To determine if the drop in iron content was due to oxidation of part of the iron removed from the main with treatment of 2 ppm metaphosphate, it was decided to add metaphosphate at the rate of 5.5 ppm. With this treatment the iron content returned to 1 ppm. The metaphosphate feed was then increased to 8 ppm and the next iron determination was found to be 1 ppm. It was obvious that for conditions existing at that time a treatment of 3 ppm was the minimum for proper control. Later in the year, as the temperature of the water and the iron content of the sample rose, the dose was increased to approximately 4 ppm.

TABLE 2

*Variations in Iron Pickup and pH on Two Typical Days* *

| Time | Oct. 24–25, 1955† | | Aug. 13–14, 1956‡ | |
|---|---|---|---|---|
| | pH | Iron—*ppm* | pH | Iron—*ppm* |
| 3:30 PM | 8.3 | trace | 6.9 | trace |
| 5:30 PM | 8.3 | 0.1 | 6.9 | 0.2 |
| 7:30 PM | 8.3 | 0.3 | 6.9 | 0.3 |
| 9:30 PM | 8.3 | 0.5 | 6.9 | 0.4 |
| 11:30 PM | 8.0 | 0.6 | 6.9 | 0.5 |
| 1:30 AM | 8.0 | 0.8 | 6.9 | 0.7 |
| 3:30 AM | 8.0 | 1.1 | 6.9 | 0.8 |
| 5:30 AM | 8.0 | 1.3 | 6.9 | 0.9 |
| 7:30 AM | 8.1 | 1.4 | 6.9 | 1.2 |

* Pump operated from 10 AM to 3:30 PM each day. All samples taken in dead-end section.
† Metaphosphate feed: 4.3 *ppm*.
‡ Metaphosphate feed: 4.5 *ppm*.

To determine the amount of iron pickup in the 4,000 ft of cleaned main while the pump was running, samples were taken on the suction side of the pump and at the end of the cleaned main farthest from the pump station. It was necessary to concentrate 1.5-liter samples in order to make this determination. Pumping at the rate of 700,000 gpd, the iron pickup was found to be 0.023 ppm, which is an iron loss of 0.012 lb per year per foot of pipe. Even this loss is insignificant when compared to the benefit of maintaining the carrying capacity of the pipe. It is possible that with the new pump installations, which will provide a much longer period of flow, greater protection against corrosion will be obtained, with a corresponding decrease in iron loss.

In all results shown in Table 3, the water sample, which had remained for approximately 19 hr in the pipeline under dead-end conditions, was collected just before starting the pump. The difference between the amount of metaphosphate added and the residual could possibly be considered as the metaphosphate demand—that is, the amount assumed deposited in the pipe. The high metaphosphate demand which prevailed immediately after cleaning the main gradually decreased over a 4-month period after the start of treatment. This fact again discloses the importance of a relatively high initial rate of feed immediately after cleaning.

TABLE 3

*Metaphosphate Added and Residual After 19 hr Under Dead-End Conditions* *

| Date | Metaphosphate—*ppm* | | |
|---|---|---|---|
| | Added | Residual | Difference† |
| Jun. 27, 1955 | 12.6 | 5.0 | 7.6 |
| Jul. 7, 1955 | 11.0 | 8.0 | 3.0 |
| Jul. 20, 1955 | 5.4 | 4.5 | 0.9 |
| Aug. 9, 1955 | 5.0 | 4.5 | 0.5 |
| Aug. 30, 1955 | 3.4 | 3.0 | 0.4 |
| Oct. 3, 1955 | 4.3 | 4.0 | 0.3 |
| Oct. 14, 1955 | 5.0 | 4.5 | 0.5 |
| Mar. 13, 1956 | 2.0 | 1.7 | 0.3 |

* Samples were collected before pump was started.
† May be considered "metaphosphate demand."

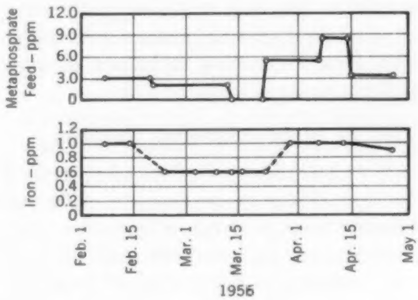


**Fig. 7. Metaphosphate Feed and Iron Determination**

*Samples for determination collected before starting pump and at same point as in Fig. 6. Temperature remained at 37°F during entire period.*

## Continuous-Flow Factor

As previously stated, the test section of pipe was purposely chosen so that the experiment would be carried out under the worst possible conditions. Under such conditions the amount of chemical feed needed to maintain the pipeline coefficient would necessarily be higher than under conditions of continuous flow. The comparatively high iron pickup in this test section disclosed that complete protection was not being obtained from the metaphosphate. It was necessary, therefore, to add more than the normal amount of metaphosphate to prevent oxidation and red-water complaints. It is felt that under conditions of continuous flow it

would be possible to decrease the rate of feed and obtain greater protection and a corresponding reduction in iron pickup.

### Test of Metaphosphate Benefits

To determine the effect of untreated Sebago Lake water on a piece of cleaned 8-in. pipe taken from the Gorham system, and to determine whether any benefit was being derived from the treatment—other than that of the dispersing effect on the iron removed from the pipe—the following test was run.

A piece of pipe was selected, approximately 8 ft long, which had been removed from the 8-in. main to insert the cleaner, and through which the cleaner had passed twice, so that this specimen was similar in all respects to the cleaned main. Through this section of pipe Sebago Lake water without chemical treatment was passed. Water was allowed to flow through for 5 hr each day and kept without flow under pressure for 19 hr, to simulate as closely as possible conditions which existed at the sampling point on the cleaned section of main in the distribution system. Samples were taken from this test specimen each day after the water had remained in the pipe for the 19-hr period. The samples averaged an iron content of about 4 ppm and had the typical appearance of red water. The test showed, therefore, that although complete protection was not being derived, 50 to 75 per cent protection against corrosion from the treatment was being given while maintaining the carrying capacity of the pipe.

The above-mentioned piece of test pipe was closed with mechanical-joint caps which were easily removed for interior inspection. After as short a period as 2 weeks, considerable corrosion and the beginning of a buildup were found.

The remaining portion of the 8-in. pipeline between the pump station and the standpipe had been cleaned recently. After cleaning the entire pipe the coefficient has been increased from the original 56 to an average of 115, with a resulting decrease in head at the same pumping rate of 100 ft, or 43 psi.

### Summary

The following summarizes the results of the experiments and tests described:

1. By pipe cleaning the pipeline coefficient was raised from 56 to 120.
2. Treatment with sodium hexametaphosphate has enabled maintenance of this coefficient without loss for 14 months.
3. There have been no red-water complaints since pipe cleaning.
4. The cost of chemical treatment as compared to the carrying charges on the cost of either water main replacement or reinforcement was small.
5. The labor cost of chemical treatment is minor; is necessary for a man to check the pumping station each day and its requires only a few minutes of his time to prepare the chemical.
6. While complete protection against corrosion was not obtained, carrying capacity was maintained. In all probability there will be some decrease in carrying capacity. If the coefficient of this pipe line does not drop below a value of 100 in 10 years, the treatment will be considered successful.

### Suggested Procedure

Whenever possible, sodium hexametaphosphate should be used at a feed rate of 2–4 ppm for as long a period as possible before proceeding

with main cleaning. This prior feed of metaphosphate has a tendency to soften the tubercles and is an aid in dispersing the sediment removed from the pipe so that it does not as readily form a plug in front of the pipe cleaner.

Before sending the pipe cleaner through the pipe on the last cleaning, ½ lb of zinc-bearing phosphate glass for each 1,000 ft of pipe to be cleaned should be inserted behind the cleaner. After cleaning the pipe it is advisable to start the metaphosphate treatment immediately as follows:

Regular metaphosphate and the zinc-bearing phosphate glass should be applied in the usual manner in proportions of 7 ppm of the latter and 8 ppm of the former. These can be mixed in the same drum and fed through a common pump. It must be borne in mind, however, that the combined feed of the two should not exceed four times the calcium present in the supply. If additional calcium is needed, this should be added to the water before the metaphosphate, either as calcium chloride or as lime.

The abovementioned combined feed should be continued for a 2-week period, after which the zinc-bearing glass feed can be eliminated. The feed will then consist of 8 ppm of regular metaphosphate. This should continue for a 3-week period. It should then be reduced at the rate of 2 ppm each week until the proper final amount is reached. The final feed should never be less than that required to maintain a metaphosphate residual four times the amount of iron in the water sampled at the end of the cleaned portion. If there is continuous flow of water in the cleaned mains, the final treatment normally is approximately 2 ppm. If the water stands without flowing in any portion of the cleaned main, it will be necessary to test for and determine how much additional metaphosphate is necessary.

The zinc-bearing phosphate glass has the characteristic of rapidly forming a coat on the interior surface of the pipe. Therefore, in order to hold the initial coefficient obtained after cleaning, it is important to use this material immediately after the cleaning as described above.

## Supplementary Data for 1957

Since the original preparation of this article, an additional year's study has been completed. The following material, derived from that study, gives results to July 1957.

Starting on Aug. 14, 1956, the remaining 7,000 ft of 8-in. pipeline between the pump station and the standpipe was cleaned in three sections. The cleaning was accomplished in the same way as in the first 4,000-ft section and was completed on Aug. 17, 1956.

The dispersing effect of metaphosphate on the old deposit was quite evident. The material removed from the pipe during the cleaning process did not collect as it came out of the main, but ran off with the water discharged from the pipe.

## Cleaning of Remaining Section

After cleaning the remainder of the 8-in. pipeline to the standpipe, regular metaphosphate and the zinc-bearing phosphate were added in the same proportion and manner as after cleaning the original 4,000-ft section of main near the pump station.

The coefficient of this 7,000-ft section was 56 before cleaning and 112 after.

On Sep. 15, 1956, two new automatically operated electric-driven pumps were put into service to replace the old electric-driven pump. The smaller

of the two new pumps, which delivers 200 gpm, carries the pumping load. The pumping time has been increased from an average of 5–6 hr per day to an average of 12–14. Furthermore, the time between pump operations has been reduced from 19 hr to a maximum of about 7 hr. The decrease of pump capacity, of course, means a decrease in flow velocity.

under different conditions; because of the automatic pumping, samples were collected 3 hr after the pump started.

Tests results have disclosed that with the longer pumping time there has been no change in the rate of iron pickup. Because of the shorter period between pump operations, the maximum iron content is decreased, but the rate of iron pickup per hour in the original cleaned section of pipe, while the pump is not operating, is the same as before the change in pumps. Likewise, while the iron content of the water at the end of the 4,000-ft section of pipe originally cleaned has increased to 0.1 ppm with the 200-gpm pump in operation, the iron pickup still amounts to about 0.023 ppm and the iron loss per year per foot of pipe remains at 0.012 lb.

TABLE 4

*Results of Iron and Metaphosphate Determinations, 1956–57*

| Date | | Pump Operation* | Iron—*ppm* | | | Metaphosphate *ppm* | | Water Temperature °*F* |
|---|---|---|---|---|---|---|---|---|
| | | | Near Pump Station | 4,000 ft From Pump Station | 10,500 ft From Pump Station | Feed | Residual† | |
| 1956 | Aug. 24 | off 18 hr | 1.2 | 1.6 | 1.0 | 15 | — | 68 |
| | Aug. 31 | off 18 hr | 1.0 | 1.6 | 0.7 | 12 | — | 64 |
| | Sep. 14 | off 18 hr | 1.0 | 1.2 | 0.6 | 8 | — | 65 |
| | Sep. 25 | on 3 hr | trace | 0.3 | 0.7 | 5 | 4.0 | 64 |
| | Oct. 18 | on 3 hr | trace | 0.3 | 0.7 | 5 | — | 56 |
| | Nov. 29 | on 3 hr | trace | 0.1 | 0.6 | 3.5 | 2.5 | 48 |
| 1957 | Jan. 10 | on 3 hr | trace | 0.1 | 0.5 | 3.5 | — | 38 |
| | Feb. 28 | on 3 hr | trace | 0.1 | 0.5 | 2.5 | — | 36 |
| | Apr. 4 | on 3 hr | trace | 0.1 | 0.6 | 2.5 | — | 40 |
| | Jun. 5 | on 3 hr | trace | 0.05 | 0.3 | 2.5 | — | 52 |
| | Jun. 20 | on 3 hr | trace | 0.1 | 0.25 | 2.5 | — | 66 |
| | Jun. 25 | off 7 hr | — | — | 0.3 | 2.5 | 1.0 | 70 |
| | Jul. 2 | off 7 hr | — | — | 0.45 | 3.5 | 2.2 | 70 |

* When sample was taken.
† For samples collected 10,500 ft from pump station.

## Results

As before, a careful record was maintained on iron pickup, metaphosphate residual, and pipeline coefficient.

Table 4 gives the results of iron and metaphosphate determinations in samples collected from points as shown between the pump station and standpipe. Samples obtained through Sep. 14, 1956, were taken just before starting the pump. This was the technique of operation during the first year's study. Samples were taken after Sep. 14, 1956,

Table 5 gives the results of coefficient tests made on various sections of the 11,000 ft of 8-in. cleaned pipe. Sec-

tion 1 is the original 4,000-ft section, Section 2 the next 3,000 ft toward the standpipe, and Section 3 the remaining 4,000 ft to the standpipe.

It is of interest to note that through Jun. 21, 1957, there has been no loss in coefficient in the first 4,000-ft section. Thus, the coefficient has been maintained without loss for 2 years since cleaning. The coefficient of Section 2 has been maintained without loss for the 10-month period since cleaning, and Section 3, closest to the standpipe, shows a drop in coefficient from the original 110 after cleaning to 90 in a 10-month period. It should also be noted that the major drop occurred in the last 2 months.

## Temperature and Flow Effects

The entire 11,000 ft of pipe shows an overall drop in 10 months from a coefficient of 115 to 110. This drop reflects the loss which has occurred in the 4,000-ft section near the standpipe.

It can be seen from Fig. 1 that practically all of the water pumped passes through the first two sections of cleaned main from the pump station to the grid system near the center of the village. The water then fans out in the grid system with resulting decrease in velocity in the last section of cleaned main. As a result, less chemical passes through the last section of cleaned pipe.

When the pump is not operating, water passes from the standpipe into the system, and when the pump operates, the water which came from the standpipe must be repumped into the standpipe before newly treated water can pass through. Thus, the pipe closest to the tank receives the least fresh chemical.

The warmer the water the more aggressive it becomes and, therefore, the greater the amount of iron that will be removed from the pipe. Further, the warmer the water the greater will be the reversion of metaphosphate to orthophosphate.

In June, the iron content dropped to 0.3 ppm in the last section of pipeline although the temperature increased to 70°F (Table 4). At the same time, the metaphosphate residual was 1.0 ppm. Apparently there was not sufficient metaphosphate residual to hold all of the iron in solution. As a result, some of the iron was building up, with a consequent decrease in coefficient on this last section.

TABLE 5

*Results of Coefficient Tests on Various Sections of Cleaned Main* *

| Date | Section | | | Overall |
|---|---|---|---|---|
| | 1† | 2‡ | 3§ | |
| Aug. 1, 1956 | 121 | 60‖ | 50‖ | 56‖ |
| Sep. 6, 1956 | 121 | 115 | 110 | 115 |
| Apr. 4, 1957 | 120.5 | 112.5 | 103 | 112 |
| Jun. 21, 1957 | 121 | 116.5 | 90 | 110 |

* All figures are $C$ values.
† 4,000 ft.
‡ 3,000 ft.
§ 4,000 ft.
‖ Before cleaning.

This is further substantiated by the fact that when the metaphosphate feed was increased from 2.5 ppm to 3.5 ppm the metaphosphate residual at the sampling point near the standpipe increased to 2.2 ppm and the iron content to 0.45 ppm. The table also indicates the result of insufficient metaphosphate feed.

This section nearest to the standpipe will be closely watched to determine the effect of maintaining a metaphosphate residual in excess of four times the iron pickup. It is hoped, on the basis of past results, that the decrease in coefficient will be greatly retarded.

## Conclusion

This study will continue until definite conclusions are reached. At the present time the authors feel that the conclusions reached at the end of the first year of study still hold. Results to date on the first 7,000 ft of pipe cleaned are quite satisfactory and it is felt that the information gained in this study will enable better control of the last 4,000-ft section.

There is no one method of water treatment that will cure all ills everywhere. The authors, therefore, strongly advise a pilot plant study under actual operating conditions before going to the expense of any contemplated change in treatment.

## Acknowledgment

The authors wish to express their appreciation to Herman Burgi Jr., treasurer and general manager of the Portland Water District, for his helpful cooperation and advice during the experiment, to the trustees of the Portland Water District for their support of the project; to J. P. Hennings, superintendent of the Portland Water District, and to his efficient crew for their excellent work in cleaning the pipe.

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# Mineral Quality of Illinois Rivers

**Thurston E. Larson and Bernt O. Larson**

*A paper presented on March 21, 1957, at the Illinois Section Meeting, Chicago, Ill., by Thurston E. Larson, Head, Chemistry Subdiv., and Bernt O. Larson, Engr., both of the Illinois State Water Survey, Urbana, Ill.*

FOR the purpose of establishing an inventory on the quality of Illinois rivers and streams, a program of sampling and analysis was begun by the State Water Survey Division in 1945. Samples were collected by field engineers of the USGS on scheduled visits to stream gaging stations once every month or every 4 weeks, and were provided to the Water Survey Division for analysis. At the time of collection the stream flow and temperature were recorded.

Data for nineteen streams at 21 locations plus Crab Orchard Lake are now available and in the process of assembly and critical analysis. The watershed areas of some of these streams are shown in Fig. 1.

## Presentation of Data

Although complete mineral analyses were made and will eventually be printed in detail, only data for turbidity, temperature, hardness, alkalinity, and total mineral content were treated graphically. Figures 2a and 2b present data from the Du Page River at Troy. In preparation of these data, the values in each category were arranged in order of magnitude; calculations were then made on the proportion of the samples (or time) for which the flow or mineral concentration was equal to, greater, or less than the specified values (Fig. 2a). Logarithmic probability paper was used as a convenient method for presentation. This method has been used previously to great advantage by Mitchell (*1*) in presenting stream flow data. The ordinate is a logarithmic scale and shows the discharge or flow in cubic feet per second per square mile, and the chemical or physical records in parts per million. The abscissa is a probability scale with frequency of occurrence or of determinations expressed as a percentage.

In these graphical presentations, the minimum values in each category are omitted as they would occur 100 per cent of the time and cannot be indicated.

It is inherent in the collection of data that maximum and minimum figures are fictitious as they represent only values that have been recorded for the number of samples collected during a given period. If more frequent samples had been collected, or if the collection period were extended, new maximum and minimum figures might be obtained. With the number of samples collected and the period, however, excellent assurance of the reliability of the median value ($\pm$ 6 per cent) is apparent and a reasonable assurance is provided to the values of the data for the range of 10–90 per cent occurrence. The actual measured amounts

are indicated for values between 0 and 10 per cent occurrence, and between 90 and 100 per cent occurrence. A best-fit curve is not continued through these points. The upper and lower 10 per cent values are isolated in this manner as a result of the relatively small total number of samples. They are,


**Fig. 1. Watershed Areas in Illinois**

therefore, not considered to be necessarily representative of the probable occurrence. Both the average daily flow from long-term records and the instantaneous flow, as recorded at the time of sample collection, are expressed in cubic feet per second per square mile in order to eliminate the variation due to size of drainage area, and to emphasize the similarity or dissimilarity of the flows.

It is of interest to note that the variability of dissolved minerals is less than that for turbidity, which in turn is less than that for flow (Fig. 2b). For 80 per cent of the samples from all sampling points, the dissolved minerals ranged from 1:3:1 in the northern part of the state, to 5–6:1 in the southern part. The turbidity ranged from 6–50:1, with the greatest magnitude for streams west of the Illinois River. Flow ranged from 10–200:1, with the greater ranges in the southern part of the state.

No attempt has been made to convert the data to indicate the quality ranges that might be expected by storage in reservoirs. Such water would be less variable in quality and possibly of lesser mineral content, depending on the newness of reservoir and the amount or percentage of runoff stored.

The turbidity, quality, and temperature data provide the design engineer with the information essential for his purposes. The time-frequency data for high turbidities are as important to the design engineer as the time-frequency of low flows. This provides information suitable for up to 90 per cent of time-occurrence and permits supplemental treatment with higher alum dosage or coagulant aids for the exceptional periods beyond the designed physical limits of the treatment capacity.

## Stream Quality

Data from the Big Muddy River at Plumfield are presented in Fig. 2c and 2d. It will be noted that the stream flow as well as the turbidity and mineral content is exceptionally variable. The extent to which acid mine wastes and brine spills from oil fields in the

area influence these data is not evident. It should be pointed out that the data are specific for the period of collection, and that, during the period, the stream flow was two or three times the normal. The mineral content was thus probably also higher.

## Sampling Representativeness

Sampling representativeness is indicated by the relation of distribution of flows, at the time of sampling, to the distribution of average daily flows established from long-term records by the USGS. It will be noted in Fig. 3 that the shape of distribution is quite similar, although a shift higher or lower than the long-term records is evident for a number of streams. This is a result of the deviation of rainfall during the period of collection from the normal rainfall, as established by long-term records. When studying Fig. 3, it appears that these deviations in flow are directly associated with deviations in rainfall during the sampling periods. Close examination of the duration curves which do not appear to be in line with most of the records, as is the one from Indian Creek, has revealed that high as well as low flows during the sample period were very much above normal, although the median flow was not. At the Little Wabash sampling point, low deviation of the median flow did not reflect the more extensive deviations during the high and low periods. This general relationship concerns only overall averages and medians and is therefore no more than indicative of a trend.

TABLE 1

*Areas of Some Illinois Watersheds*

| Watershed | Symbol (Fig. 5) | Area *sq mi* |
|---|---|---|
| North | | |
| Du Page | a | 325 |
| Green | b | 1,080 |
| Mackinaw | c | 1,100 |
| Iroquois | d | 682 |
| Salt Creek | e | 334 |
| Vermilion | f | 959 |
| Kaskaskia (upper) | g | 1,980 |
| West | | |
| Spoon | h | 1,070 |
| Indian Creek | i | 37 |
| Macoupin | k | 875 |
| La Moine | l | 1,310 |
| South | | |
| Kaskaskia (lower) | m | 5,220 |
| Little Wabash | n | 1,130 |
| Skillet Fork | o | 475 |
| Big Muddy | p | 2,360 |
| Saline | r | 1,040 |

## Quality and Stream Flow

Although the probability distribution curves for quality appear to be related to the stream flow by this manner of presentation, this is true only in a general sense as the higher concentrations of turbidity and the higher discharge rates occur at about the same time and with similar frequency. The corresponding turbidities and flow rates, however, are not necessarily related, as is shown in Fig. 4. It will also be

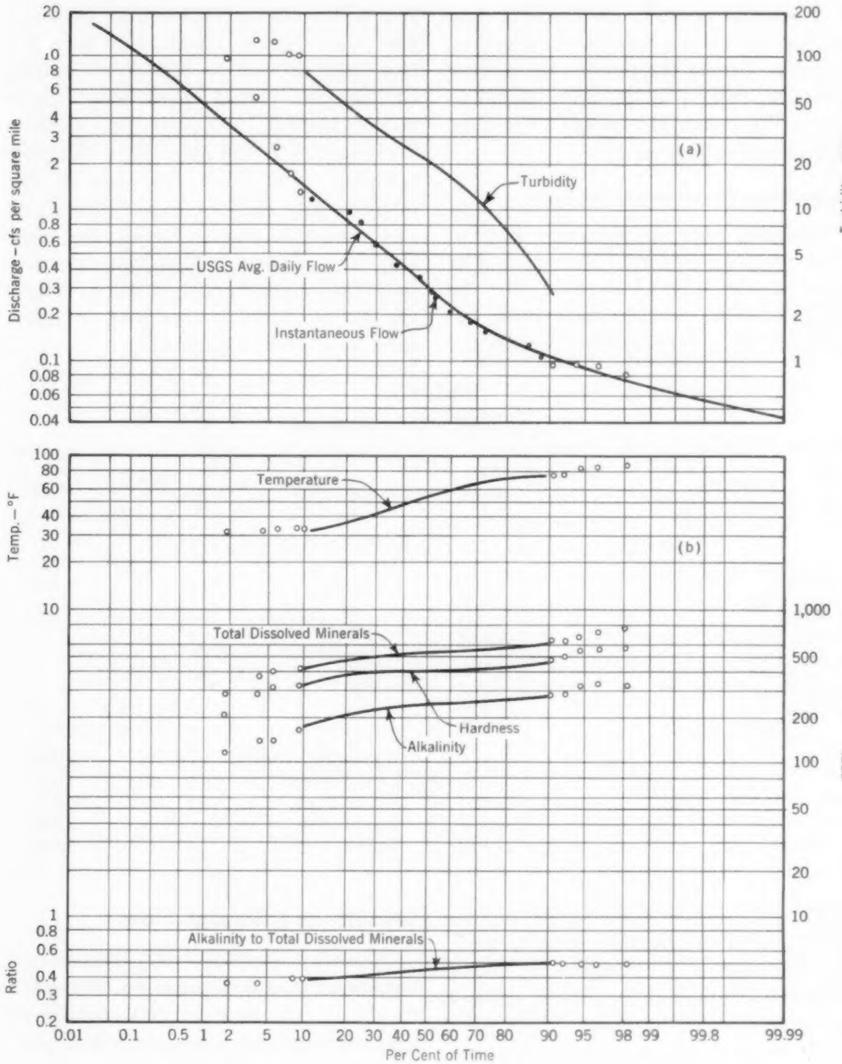


**Fig. 2a, 2b. Record and Analyses of Du Page River at Troy**

*The normal annual rainfall in the river's watershed is 33.64 in., and the departure from normal during the 5-year test period was + 0.90 in. Figures 2c and 2d, referring to the Big Muddy River at Plumfield, are shown on the following page.*

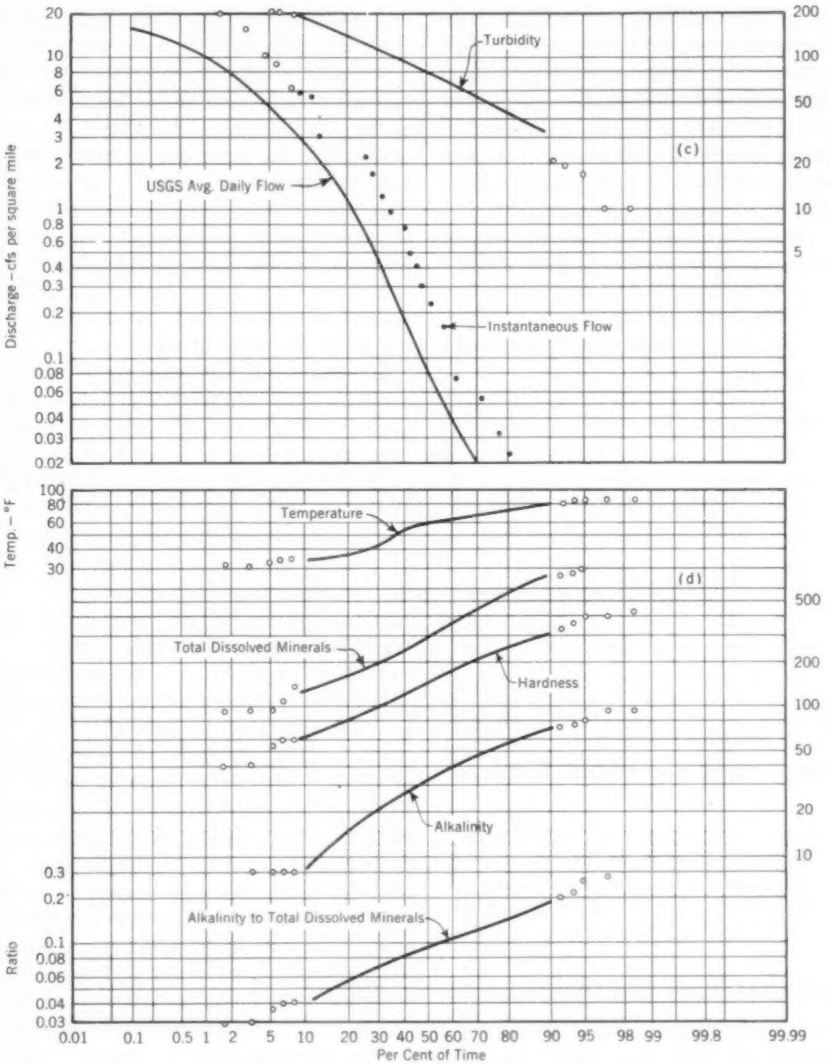


**Fig. 2c, 2d. Records and Analyses of Big Muddy River at Plumfield**

*The normal annual rainfall in this watershed is 40.49 in., and the departure from normal during the 5-year test period was + 8.45 in. The wide range in mineral content (Fig. 2d) should be compared with that of the Du Page River in Fig. 2b. [Note: Space did not permit extension of the lower end of the discharge curve in Fig. 2c to show that 0.001 cfs per square mile was exceeded 97 per cent of the time.]*

noted that the dissolved minerals, as well as the alkalinity and hardness, are not directly related to the corresponding flow rate. Here again, the relation is general and not specific. In other words, a measure of the total mineral content is not an indicator of the flow rate, nor is the flow rate a specific indicator of the mineral content that may be present at the time. It should, of course, be obvious that this specificity is not to be expected as a result of the many variables concerned with the mineral quality of any water and with stream flow.

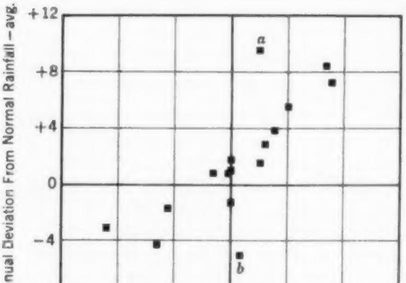


**Fig. 3. Relation of Medium Discharge to Rainfall**

*Excess rainfall results in greater than—and deficient rainfall in less than—normal discharge. Data for two streams* (a, *Indian Creek; and* b, *Little Wabash*) *are discussed in the text.*

## Watershed Area and Physiography

It was recognized immediately on inspection of the data that, for the streams as a whole, there was little or no relation between watershed area and variability in stream flow or in water quality. This discovery diverges from the general conception that variability of stream flow is related to watershed area, but it is not incompatible. It may be considered normal for stream flow and quality to be more highly variable near the source than downstream as: [1] there is greater probability for no rainfall and no runoff for increasingly small watersheds; [2] there is less probability for sustained ground water contribution from small watersheds than from large watersheds; and [3] tributaries tend to become integrated and equalize the flows and qualities. A large tributary, however, can markedly change the flow and the quality of water in the main stream.

In the Illinois watersheds which measure from 37 to 5,220 sq miles, area appears to have so little influence, however, that it must be considered as inconsequential. The flow and quality at the source of each tributary as well as for the integrated main stream must be dependent on the physiography of the respective watersheds. The recorded features of the streams have thus been compared on this basis.

In Fig. 5 and Table 1 the following data for each internal stream are given: [1] the watershed areas; [2] the general soil classifications of the University of Illinois Agronomy Department *(2)*; [3] Lane's variability index *(3)* calculated for each stream from long-term daily flow records; [4] the hardness; [5] the total dissolved minerals; and [6] the turbidity. The data for hardness, minerals, and turbidity indicate the median and the lower and upper 10 per cent values of the determinations.

The variability in stream flow is low in the northern Illinois streams (the DuPage and Green rivers) where physiographic conditions are conducive to high ground storage capacity and hydrologically permit contribution of ground water to stream flow at low flow periods. This same physiography is responsible for the relatively low

position. The soil associations, that is, the relationships of the component soil types, indicate the subsoil of the watersheds to be calcareous glacial loam till of Wisconsin age. Ground waters are very hard and surface runoff is also exposed to the richly mineralized soil of recent glacial origin.

Farther south in the lower two-thirds of the Wisconsin glacial area, a trend exists toward a somewhat greater variability in stream flow, with lesser ground water contribution for the Mackinaw, Iroquois, Salt, Vermilion, and upper Kaskaskia streams. Soil associations indicate a somewhat thicker loess * of 0–5 ft on calcareous till sub-

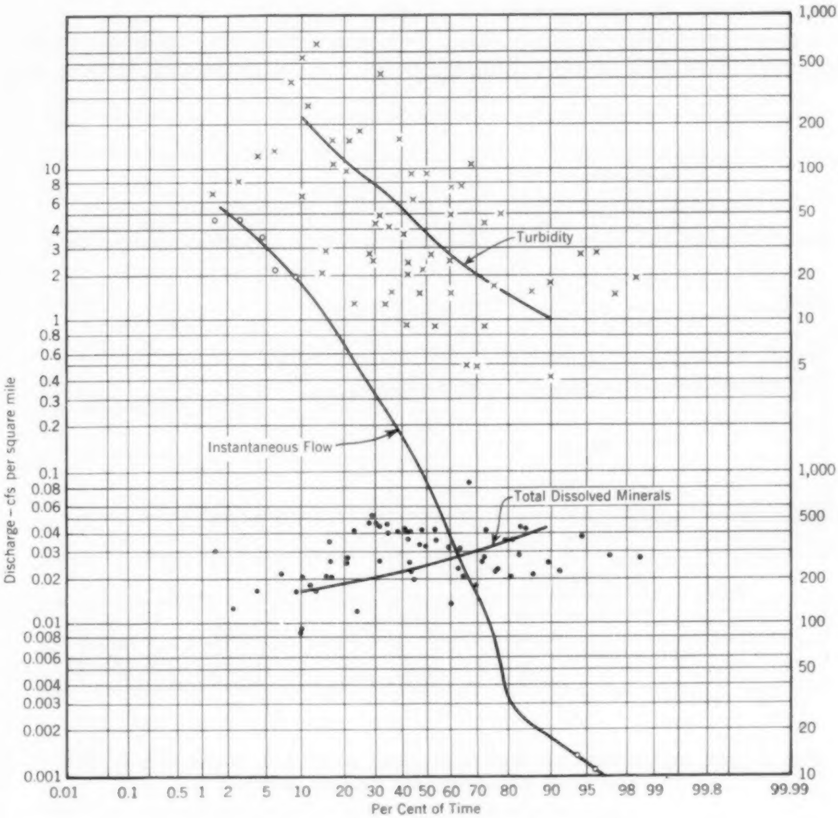


**Fig. 4. Little Wabash River Analysis**

*The graph shows that high turbidities and flow rates are not necessarily related. Turbidity corresponding to the flow rate is indicated with crosses; total dissolved minerals corresponding to the flow rate, with black circles.*

* A loess is an unstratified deposit of yellowish-brown loam, now thought to be chiefly borne or produced by the wind.

soil. The lesser ground water contribution results in a slight general decrease in hardness toward the southern end of the Wisconsin glacial boundary.

Continuing southward through the area where the Wisconsin glacial deposits are absent, the physiography dictates greater variability of stream flow. The lower Kaskaskia at New Athens period. The subsoils are of very fine texture and are very slowly permeable. Thus, the subsoil ground water contributions are negligible—in fact, the available ground water is virtually nonexistent toward the southern end of the state.

Greater variability in mineral composition is evident in these streams and

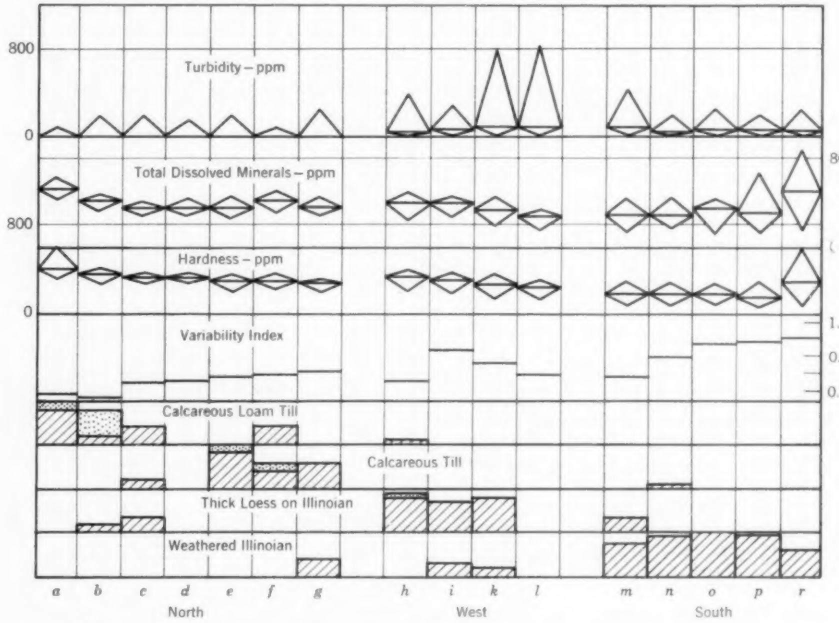


**Fig. 5. Soil Associations for Watershed Areas Related to Water Quality Data and Flow Variability for Various Rivers**

*A key to the rivers and watersheds is given in Table 1.*

is influenced by the contributions from the Wisconsin drift at the upper third of its watershed above Shelbyville. The variability in flow for the other streams increases from the Little Wabash to the Skillet Fork, the Big Muddy, and Saline rivers.

Soil associations show a weathered till subsoil of the older Illinoian glacial a general decrease in hardness is noted. Seepage from bedrock may be a factor in mineralization. At least one flowing salt well is known to exist in the Saline watershed. This well and possibly others may contribute to the high mineral content and hardness. As the character of the mineralization in these streams is also highly variable, occa-

sional high mineralization in the Big Muddy as well as the Saline may also be a result of mine wastes or brine spills at the oil fields.

Northward, to the western side of the state, there is no general trend in variability of flow or mineral composition, although both may be considered as intermediate between those for the Wisconsin glacial watersheds and the thin leached Illinoian watersheds in the south. Thick loess of 5 to more than 8 ft covers weathered Illinoian or Kansan till.

It is notable that a greater turbidity is evident, particularly from La Moine, Macoupin and Spoon River watersheds. This turbidity may be attributed to the recognized thick loess deposits of wind-blown till, often exceeding 9 ft in thickness in this western part of the state. The high turbidities are also noted to

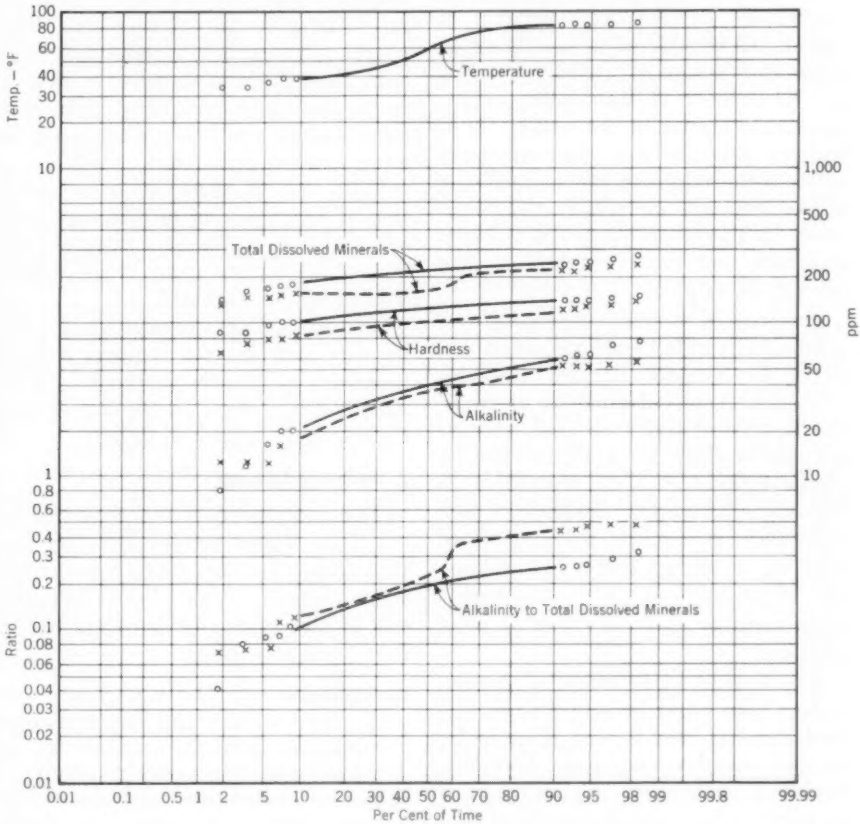


**Fig. 6. Crab Orchard Lake Analysis**

*Samples were taken at two different points in the lake—one indicated with circles, the other with crosses.*

a lesser extent in the Kaskaskia waters nearby, particularly at New Athens.

From the standpoint of treatment, turbidity is of appreciable significance to the water plant operator. From the standpoint of reservoir sedimentation, however, turbidity which is determined empirically by the transmittance of light is not considered as significant as suspended solids. Suspended solids are determined as the weight of the suspended matter in the water. It is entirely possible that the suspended solids in the waters of the western part of the state are no greater than elsewhere, but are more finely divided and, therefore, are more resistant to the passage of light.

Analyses of samples collected at two points in Crab Orchard Lake are shown in Fig. 6. The data illustrate the relatively low dissolved minerals as result of a watershed with thin loess, only 30 per cent of which covers thin weathered glacial deposit, with the remainder on bedrock. They also illustrate a low variability in quality resulting from blending in storage and a low proportion of alkalinity in the dissolved minerals, possibly partly a result of mine drainage.

The low mineral content of surface waters from watersheds in the unglaciated area has been further reflected by isolated samples from Lake Glendale, having a watershed of less than 2 sq miles, and consisting entirely of thin loess on bedrock. These samples and others from ponds in the vicinity have been noted to have a total dissolved mineral content of 50–70 ppm.

## Conclusions

The range of quality in Illinois streams has been covered—from water of relatively high mineral content and hardness in areas of recent glacial origin at the northern end, to waters of very low mineral content in areas of no glaciation at the southern end. The notable divergences, resulting from thick loess deposits on the western side of the state, and from brine spills, acid mine wastes, and flowing salt wells in other isolated areas were noted.

With the establishment of the relation of water quality to dominant parent material in the soil patterns, the quality of waters from other watersheds may be estimated.

The method of presentation of quality data provides the engineer with a frequency of occurrence range of data which should result in the use of less hypothesis in treatment design.

## Acknowledgment

The cooperation of the personnel of the State Water Survey Division and the engineers of the USGS is gratefully acknowledged. Without their help, the cost of a program of this nature would have been prohibitive.

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# Oxidation-Reduction Potential Measurements Applied to Iron Removal

James G. Weart and Gerald E. Margrave

*A paper presented on Mar. 22, 1957, at the Illinois Section Meeting by James G. Weart, Chief Chemist, Div. of Labs., and Gerald E. Margrave, San. Engr., Bureau of Public Water Supplies, both with the Illinois Dept. of Public Health, Springfield, Ill.*

THE purpose of this article is discussion of the application of oxidation-reduction potential measurement to water treatment for iron removal.

Oxidation-reduction (redox) potentials express the intensity of the oxidizing or reducing properties of a solution. Redox potentials, although dependent on ion concentrations, express only the intensity of oxidation or reduction and give no evidence of the amounts of oxidized or reduced ions composing the system. In the waters studied, the redox potentials observed represented the net intensity of all oxidants or reductants present. The redox values obtained are thus somewhat comparable to pH values, which express the intensity of acidity or basicity of a solution, but do not measure the amount of acid or alkali which might be present. In potable waters, oxidizing substances which may be encountered are chlorine, dissolved oxygen, and ferric iron. Ferrous iron, soluble sulfides, and soluble organic materials are examples of reducing substances.

### Determination Technique

Redox potentials of water are determined by observation of the potential difference exhibited between platinum and saturated-calomel electrodes immersed in the water. This potential is conveniently measured with a standard pH meter. For the field work described here, a battery-powered, pH meter * was used. A glass electrode was mounted on the instrument, and a simple change of connecting leads permitted pH measurements. Flow samples were carried through rubber tubing from sampling cocks located at various stages of treatment and were discharged into a plastic flow cell at the pH meter. The flow cell was a quart size plastic bottle with a portion of the top cut off. A constant water level was maintained by using a piece of plastic tubing as an automatic siphon which discharged continuously to waste and from which samples were collected for all analysis purposes except redox potential and pH. These values were read directly on the meter after submerging the electrodes in the flow cell and allowing time for stabilization. This method proved very convenient, for the long length of tubing permitted samples to be collected at all points in most plants without moving the meter and other equipment.

The observed potential, using the saturated-calomel electrode as reference, was corrected to the potential of

* The meter used was a Beckman Model N, a product of Beckman Instruments, Inc., Beckman Div., South Pasadena, Calif.

the normal hydrogen electrode, the value of which is zero. This is illustrated by the following equation:

$$E + E_c = E_h \text{ (redox potential)}$$

in which $E$ is the potential of the system as measured with the saturated calomel electrode as reference, in millivolts; $E_c$ is the potential of the saturated calomel electrode with reference to the normal hydrogen electrode, in millivolts; and $E_h$ is the potential of the system with reference to the hydrogen electrode. As the value of $E_c$ at 25°C is 244 mv, $E_h$ is equal to $E + 244$ mv.

Redox potentials are affected by both the pH value and the temperature of the water. In this study no corrections were made for these factors because all the waters were of essentially the same pH value and temperature. The use of this measurement with lime-softened waters or surface waters of variable temperature would require moderate corrections for pH and temperature.

In studies of the relation of the corrosive nature of soils to anaerobic bacterial activity, redox potentials have been effectively used (*1*). These measurements have also been reported as more useful in the determination of biological activity in water than the dissolved-oxygen test (*2*). Redox potential measurements were employed in this study in an attempt to explain the varied performance of iron removal plants. The usual information on mineral quality failed to provide this explanation.

## Iron Removal in Illinois

Illinois, which is one of the "hard-water states," should also be included in the iron-bearing water list. Two of every three of Illinois' well water supplies contain 0.4 ppm iron or more. Forty per cent of public well water supplies contain iron in excess of 1.0 ppm. Because water with an iron content in excess of 0.3 ppm is objectionable as a public water supply and because iron removal is a practical method of water treatment, the number of public water supplies in Illinois which employ iron removal treatment has increased rapidly in the past 35 years. In 1921, Illinois had only one such plant; in 1934, six, and today, about 170 municipal plants provide iron removal treatment. About 50 per cent of these plants use iron removal alone, for its own value, and the remainder remove iron as pretreatment to ion-exchange softening.

The Illinois Department of Public Health has observed the performance of these plants for a number of years. This has been accomplished primarily by determination of the iron content of representative samples submitted each month to their laboratories. A study of these analyses indicates that although a number of plants consistently reduce the iron content to less than 0.1 ppm, there is a significant number of these plants which do not reduce the iron content below 0.3 ppm.

Unsatisfactory performance of an iron removal plant may result from improper operation, inadequate design in relation to the quality of water available, or to a combination of these factors.

Information on the mineral quality of the untreated well water at each of these plants is available from complete mineral analyses made by health department laboratories and by the State Water Survey Division of Urbana, Illinois. From this information, it is apparent that the iron content of the well

water is not a significant factor in the iron removal efficiency. For example, one Illinois municipal plant, doing an excellent job of iron removal, has an iron content in the raw well water of 25.8 ppm.

Unsatisfactory iron removal is largely confined to those plants where water is obtained from wells in the glacial drift. Drift wells obtaining water from the pre-Wisconsin drift (Illinoian and Kansan) have typical high-alkalinity waters with an excess of sodium bicarbonate. These waters are more particularly noted for the absence of sulfate and nitrate, and a moderate to high ammonium content. Waters from wells in the Wisconsin drift are lower in alkalinity, and usually contain sulfate and nitrate, but are free of ammonium. There are, of course, mixed waters which show some characteristics of both types.

It is quite significant that the major problems in iron removal are found at those plants using drift well water of the first-mentioned type—sulfate-free, ammonia-bearing, sodium bicarbonate water.

**Preliminary Investigation**

In 1952, several representative plants were selected for a more detailed investigation in order to study the relative performance of plants operating at both high and low efficiencies. Field measurements for dissolved oxygen, ferrous and ferric iron, and pH values were made on samples of untreated, aerated, and filtered water. Microscopic examinations of samples of water and slimes were also included.

Each of the plants studied employs essentially the same treatment process. Raw water from the well is pumped to an aerator from which it flows to a basin providing a retention of 1 hr (based on the capacity of the high-service pump). The aerators are principally of the coke tray type, although a few plants use the forced-draft type. The high-service pump takes suction from the retention basin and discharges to a pressure filter.

In all instances, waters as pumped from the wells were free from dissolved oxygen, and the iron content was all in the ferrous (reduced) state. These waters, after aeration and retention, as applied to the filter, contained 7–9 ppm of dissolved oxygen, or only 80–85 per cent of saturation. In most instances this treatment oxidized a large part of the iron, although, at some plants, aeration to this degree resulted in only partial oxidation. The dissolved oxygen present in the filter influent was reduced or was completely removed as the water passed through the filter. In those plants with unsatisfactory iron removal, the ferric iron present in the filter influent reverted in part to ferrous iron during filtration.

Observations of the interior of the filters at many plants revealed surprising differences. At those plants with effective iron removal, there was little or no gelatinous slime growth on the filter shell or on the filter media. At those plants with unsatisfactory results, vigorous gelatinous slime growths were commonly found. These growths served as effective deoxygenators, which resulted in the filter unit performing as a trickling filter in reverse. Although this information was useful, it failed to explain the reasons for unsatisfactory operation. No remedial recommendations could be made, nor could design suggestions be formulated to avoid these difficulties in new plants.

## Plant Study

In 1954, additional on-the-site studies were undertaken at a larger number of plants. To supplement determination of ferrous and ferric iron, dissolved oxygen, pH, and microscopic examinations, redox potential measurements were made on raw, aerated, and filtered

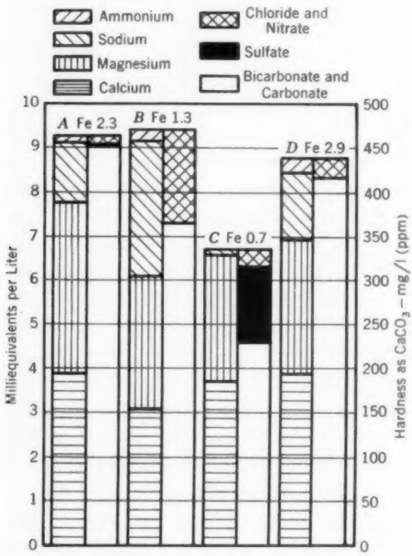


**Fig. 1. Composition of Typical Waters**

*Total hardness is measured to the top of the magnesium segment. Analysis* C *is of a water containing noncarbonate hardness;* A, B, *and* D, *bicarbonate hardness only.*

water. Conditions existing in aerators, retention basins, filters, distribution systems, and toilet flush tanks were also observed.

This more detailed study indicated that the problem could be correlated with water type. Sixty-seven iron-removal plants, considered to be representative of the two principal types of water used, were selected for further study. These plants, located in all portions of Illinois, but largely concentrated in the drift well area in the central section, were checked for iron removal efficiency. The records indicate that there has been no significant change in the performance of these plants over a period of years.

## Water Type and Plant Performance

This special study confirmed previous observations that not all waters respond equally well to the conventional processes used for the removal of iron. Further study of mineral analyses of waters treated at these 67 plants showed that they fell into two general categories: those containing sulfate but no ammonium and those containing ammonium and little or no sulfate. The former waters usually contain noncarbonate hardness and the latter are generally known as sodium bicarbonate waters. Analysis of plant operations combined with a check of water types revealed the need for further division of the ammonium-bearing sodium bicarbonate waters into two subclasses: those containing both ammonium *and* sulfate and those containing ammonium and *no* sulfate.

The composition of these types of water is shown in Fig. 1. The heights of the sections are proportional to the quantities of the constituents as measured in milliequivalents. Four constituents are shown in the left bar and three on the right bar of each double-bar analysis. The total hardness is measured to the top of the magnesium. The carbonate hardness is measured to the top of the bicarbonate if it is below that of the magnesium. In such a water, the distance from the top of the bicarbonate to the top of the magnesium measures the noncarbonate hardness. If the bicarbonate extends above the

magnesium there is no noncarbonate hardness; the water has more alkalinity than hardness and is commonly said to contain sodium bicarbonate. Analysis C shows a typical water containing noncarbonate hardness, and Analyses A, B, and D show bicarbonate waters (*3*).

Figure 2 illustrates an analysis of plant operation based upon the types of waters used. Water Type A contains sulfate and only traces of ammonium, if any, and have noncarbonate hardness. Twenty-eight plants are represented in this classification, and it can be observed that 64.2 per cent produce an effluent averaging less than 0.2 ppm iron. Many of these plants consistently produce an effluent averaging less than 0.1 ppm iron. Of the 28 plants, 17.9 per cent produce a final water averaging between 0.2 and 0.3 ppm iron, and 17.9 per cent distribute a water in which the iron content averages over 0.3 ppm.

Type B is a bicarbonate water containing both ammonium and sulfate, although the latter may be present in only small amounts, such as 2.0 ppm. Represented in this group are 22 plants. It can be seen from the chart that the performance of plants using this type of water is essentially the same as those using Type A. Of these, 63.7 per cent produce a water with an average iron content of less than 0.2 ppm, 13.6 per cent a water averaging between 0.2 and 0.3 ppm iron, and 22.7 per cent with an average iron content of over 0.3 ppm in the final water.

Special attention is directed to plants using water of Type C. Although a bicarbonate water, as is Type B, it is somewhat different chemically as this type contains ammonium but *no* sulfate. Represented in this compilation are seventeen plants. It is interesting to note, in comparing plant operation of those using this type of water to those using Types A and B, the large difference in percentage of those producing a final effluent containing an average iron content of more than 0.3 ppm. To be specific, 70.6 per cent of these plants distribute a water containing iron in amounts above this generally

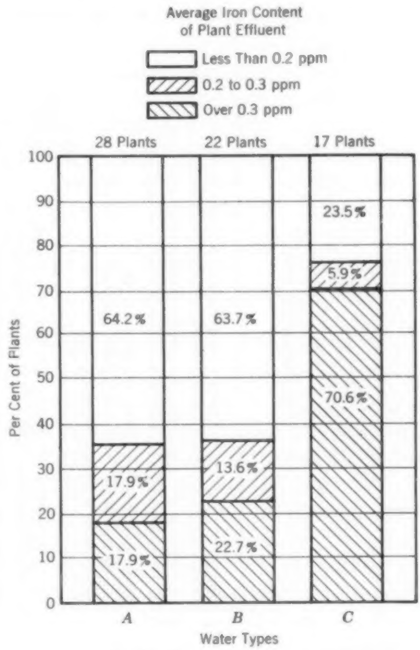


**Fig. 2. Analysis of Plant Performance**

*Water Type* A *contains noncarbonate hardness;* B, *bicarbonate hardness only with ammonium and sulfate;* C, *bicarbonate hardness only with ammonium, but no sulfate.*

accepted limit. The average iron content of the final water from 5.9 per cent of these plants falls between 0.2 and 0.3 ppm, and only 23.5 per cent produce a water with an average iron content of less than 0.2 ppm. The striking difference in percentage of plants operating

inefficiently using water of Type C as compared to those using Types A and B cannot be attributed to poor operation, and, in the opinion of the authors, is significant. It is concluded that water quality must be a design consideration.

## Potential Measurements

Because an iron-bearing water constitutes a redox system, and the attendant treatment processes modify this system, redox measurements were further adopted to differentiate water quality and to determine more completely the conditions existing in the various stages of water treatment.

Figure 3 shows the data obtained in making redox measurements. The scale for the redox potential, with reference to the hydrogen electrode, $E_h$, is shown as the ordinate and is expressed in millivolts. Twelve plants studied are shown as the abscissa. The top of the lower section of each bar shows the redox potential for the raw water, and the tops of the upper sections the potential of the water after aeration. The bar representing Plant 12 has a third section, the top of which represents the potential of the filter influent which has been treated with chlorine prior to aeration.

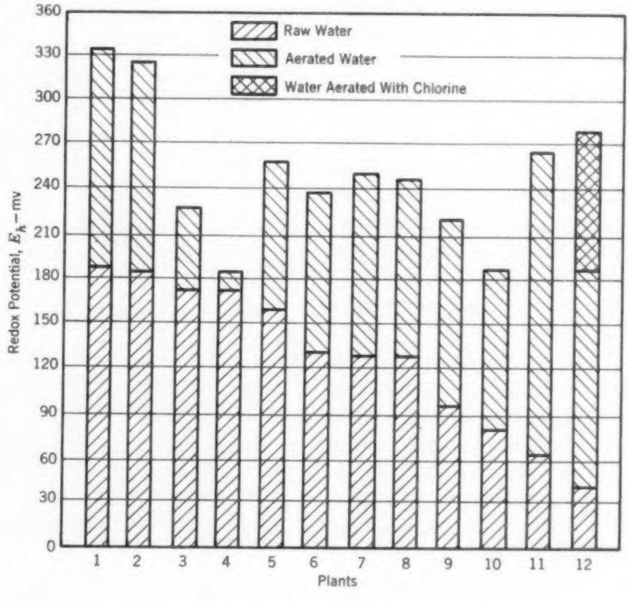


**Fig. 3. Data Obtained With Redox Measurement**

*All plants indicated are in Illinois.*

In connection with this chart, reading from left to right, the descending potential of the various raw waters should be noted. This illustrates rather clearly marked differences in water quality. Such differences are not detectable by

present methods of chemical analysis. but are readily detectable by redox measurements. This new method, as previously noted, is strictly an intensity measure. The relatively low redox potentials of the waters represented on the right portion of Fig. 3 are the result of the presence of reducing substances other than iron. The presence of reducing substances in water may also be detected by tests for chlorine demand, chemical oxygen demand, or biochemical oxygen demand. Although tests of this nature are not readily adaptable to plant operation studies, there has been found a direct correlation between low redox potentials and these determinations.

That these reducing substances are organic in nature is confirmed by the fact that in those waters represented with low redox potentials on the right portion, the iron organisms, *Crenothrix* and *Leptothrix,* have been found. These are commonly encountered in waters containing relatively large amounts of organic matter (*4*).

In those waters with a higher redox potential on the left side of the chart, the iron organism *Gallionella* was found. This form is encountered in waters low in organic matter (*4*).

A low redox potential in the raw well water, however, does not necessarily indicate unsatisfactory plant performance. The response of the water to aeration, as measured by the redox potential, is an important consideration. An example of this is Plant 11 (Fig. 3), where plant efficiency was satisfactory.

When aeration alone will raise the redox potential of a water to a level approaching + 244 mv, the plant will function satisfactorily, provided reasonable care is given to operation. It was noted that in most plants using bicarbonate waters containing ammonium but no sulfate, and with a low initial redox reading, the potentials of these waters could not be raised to satisfactory levels with aeration alone. Supplementary treatment with an oxidant such as chlorine is essential and has proved to be effective in maintaining an oxidizing environment.

A comparison in Fig. 3 of the redox potentials of raw well waters and their response to aeration suggests an initial potential level of + 100 mv, above which iron removal is satisfactory, and below which iron removal is not satisfactory with conventional treatment. This is similar to the classification of Starkey and Wight (*1*) in their study of the relationship of redox potentials of soils to corrosiveness.

The shift in the redox potential during filtration was an informative index of filter conditions and of iron removal efficiency. In most plants using waters of Type C (ammonium, but no sulfate), the redox potentials of the filter effluent reverted towards that of the raw well water, and the dissolved oxygen originally present in the influent was depleted. Under these conditions, complete anaerobiosis existed in the filter, and some ferric iron was reduced to the soluble ferrous state with resultant low iron removal efficiency.

At those plants with satisfactory iron removal, there was no significant shift in the redox potential of the water during filtration, even though the dissolved oxygen content was reduced. This common depletion of the dissolved oxygen during the rapid passage of water through an iron removal filter is a sure indication of an extremely active biological flora and fauna.

## Oxidizing Environment

There may be some question as to whether biological growth is undesirable in a filter. At first this was assumed to be a detriment to efficient operation. There is some evidence, however, that certain bacteria may actually aid in the oxidation of a portion of the ferrous iron not acted upon during the aeration process. In some plants utilizing ammonia-bearing waters, it has been observed that residual ferrous iron is removed by passage of the water through the filter. This has been observed to occur in those instances where aerobic conditions exist in the entire filter, as evidenced by the presence of some dissolved oxygen in the effluent, a shift in the redox potential to a higher level, and the occurrence of nitrification.

Water with ammonium present has a definite oxygen demand when, in the filter process, ammonium is oxidized to nitrate by the activity of nitrifying organisms *(6)*. Because of the ubiquity of these bacteria, they will appear wherever ammonium is present and aerobic conditions prevail *(5)*, and, provided oxygen is available, a vigorous nitrifying flora can be expected to develop. The flora consists, in the main, of organisms belonging to the genera *Nitrosomonas* and *Nitrosococcus,* which are responsible for the oxidation of ammonium to nitrite, and *Nitrobacter,* which oxidizes nitrite to nitrate. Thus, with an oxidation reaction proceeding under aerobic conditions, the situation is extremely favorable for the oxidation of residual ferrous iron which may be present in the water, and the maintenance of the ferric state.

An aerobic or oxidizing environment is, perhaps, a most significant factor in obtaining effective iron removal. While the oxidation of 1 ppm of iron theoretically requires only 0.14 ppm of $O_2$, approximately 5 ppm of $O_2$ are required in the complete oxidation of 1 ppm of $NH_4^+$ *(6)*. In certain Illinois waters, therefore, some of which contain as much as 20 ppm ammonium, it is not possible to maintain the desired aerobic conditions with only the dissolved oxygen normally introduced into the water during aeration. Such were the conditions in one municipality which requested assistance. The village officials had had many complaints of dirty water and objectionable tastes and odors in the public water supply. An investigation revealed that the primary difficulty was the poor iron removal efficiency at the water treatment plant. Tests indicated typical anaerobic conditions which reverted ferric to ferrous iron in the pressure filters.

The use of chlorine was considered to correct this condition. Free residual chlorination was not practical because of the presence in the water of 4 ppm of ammonium, and a high chlorine demand. Marginal chlorination was adopted in an attempt to control excessive growths in the treatment units. Chlorine was applied to the well pump discharge, ahead of the aerator, at a rate of 6 ppm. A combined chlorine residual of about 0.5 ppm is maintained in the final plant effluent. As a result of this treatment, iron removal efficiency has materially improved and distribution system complaints have dropped to a minimum. Aerobic conditions now exist throughout the plant and extend into the distribution system. The effect of chlorination on the redox potential of this water is shown in Fig. 3 (Plant 12).

Several important facts were established as a result of this experiment:

1. Redox potential measurements on the filter effluent water indicate im-

provement in conditions in the filter long before such change could be detected by dissolved oxygen and residual chlorine measurements.

2. Marginal chlorination preferentially and quickly oxidizes ferrous iron before complete combination of the chlorine with ammonium.

3. Once filters are seeded with iron organisms and objectionable slimes and anaerobic conditions prevail, the filters apparently cannot be cleaned to produce effective iron removal by chlorination.

4. It is difficult to eliminate growths in an old filter even though the old medium is removed, the shell thoroughly cleaned, the medium replaced, and the unit thoroughly disinfected with chlorine.

5. It is possible to maintain a new filter shell and new media free from excessive growth by marginal chlorination, provided chlorinated water only has been in contact with the unit.

6. This type of treatment has a beneficial effect upon the undesirable conditions existing in the distribution system.

A recent inspection of toilet flush tanks at representative points on this distribution system showed a marked reduction in the slime growth formerly present. In fact, the tanks are now practically free of growth whereas, initially, the growth was heavy and gelatinous. A slight trace of chlorine was detectable well toward the end of the distribution system—a condition which previously had not existed.

## Causes of Inefficiency

Earlier in the study of efficiency of iron removal plants, it was estimated that 25 per cent of the plants were operating ineffectively. Referring to Fig. 2, it can be seen that this estimate was fairly accurate. The fact that between 20 and 25 per cent of all plants are producing an effluent containing over 0.3 ppm iron is an unsatisfactory situation. It can, in part, be attributed to a number of operational deficiencies.

In many instances it has been determined that filter runs are too long. The operator may backwash the filter when the pressure gages indicate the prescribed head loss, but the gages are generally not too reliable. If the filter is overrun, iron completely penetrates the filter media and bleed-through results. The proper filter cycle should be frequently determined for each installation by the examination of samples for total iron content during the filter run rather than by the use solely of loss-of-head gages.

Inadequate backwashing of the filter media is an important reason for poor operation in many iron removal plants. To assure adequate backwashing, sufficient freeboard must be allowed to permit proper filter bed expansion. Very often, however, this result cannot be attained. In the initial loading of the filter shell, or replacement of the filter media, the required freeboard may not be provided. When gelatinous slime growths are present, sand bulking results, and the original freeboard is materially reduced. Precipitation of calcium carbonate on the sand grains, an action which is quite general, will tend to produce the same effect, and can become serious when combined with the presence of slimes. Gelatinous slime growths can also clog filter media to the point where channeling and uneven backwash occur. At times, filter sands were observed to be so seriously clogged that ponding occurred when the filter was drained.

One disadvantage of pressure filters, which are used almost exclusively in iron removal plants in Illinois, is the inability of the operator to observe the

condition of the filter at any time. If the manhole is removed for observation purposes, it is difficult to take corrective action, if any is indicated, because of the construction of the filter shell and the limited working space. An extreme example of this lack of ability to observe recently occurred at one plant experiencing difficulty. On opening the filter, only 4 in. of sand was found.

In some plants, particularly in smaller communities where a water supply is available for the first time and consumption is much below normal design capacity, intermittent or short-period operation can be an unfavorable factor in iron removal efficiency.

It is common practice in all iron removal plants for the high-service centrifugal pump to take suction from the retention basin. Theoretically, the water is retained in this basin after aeration for the completion of the oxidation reaction, and for the formation of a filterable floc. The handling of any flocculent material by a pump prior to filtration is contrary to accepted practice in other types of water treatment.

## Conclusions

It is hoped that this report will stimulate additional investigations and research so that increased iron removal efficiency can be attained through proper plant design and operation.

The results of this investigation indicate that:

1. Redox potential measurements are a helpful tool in evaluating iron removal plant efficiency.

2. Redox potential measurements clearly indicate that waters vary in quality, in ways not always apparent from examinations made by other presently known methods and techniques.

3. A critical redox potential value for raw waters can be selected which will indicate, within limits, those waters which may not be amenable to treatment by conventional iron removal processes.

4. Water quality *must* be considered in plant design.

5. Additional basic research and study on various phases of iron removal is necessary to assure efficient removal of iron from various types of waters. Examples of areas in need of further investigation are:

*a*. Chemical and bacteriological investigation, microscopic studies, and redox potential measurements leading to the development of new techniques and methods of analysis of water quality

*b*. Determination of desirable rates of aeration and aerator efficiencies, particularly in reference to the oxidation of iron, and their relationships to water quality

*c*. The effectiveness of retention basins as now designed; the speed of the iron reaction, and the retention period required for completion of the reaction as related to water quality

*d*. The mechanism of removing iron by filtration, filtration rates, efficiencies of different types of filter media and their correlation with the various chemical, physical, and biological factors associated with the filtration of iron-bearing waters

*e*. Reconsideration of the basis of design of iron removal treatment plants in relation to the types of water to be treated.

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# Climate, Fluid Intake, and Fluoridation

The June 1957 issue of *Public Health Reports* carries a report by Galagan, Vermillion, Nevitt, Zachary, and Dart. Summarized the report states:

1. Records of fluid intake for 455 Antioch and Brentwood, Calif. children from infancy through 10 years of age were obtained during thirty-nine 5-day observation periods covering 1 year. Detailed temperature and humidity data also were obtained throughout the year.

2. Rank order correlations showed that any one of several expressions could be used to describe the climatic variables—temperature and humidity. The terms maximum temperature and minimum humidity were selected.

| Fluid Consumed | Antioch | Brentwood |
|---|---|---|
| Drinking water | 33.8 | 36.4 |
| Water-based beverages | 9.6 | 11.2 |
| Milk | 47.9 | 39.9 |
| Carbonated beverages | 3.0 | 3.6 |
| Other fluids | 5.7 | 8.9 |
| *Total* | 100.0 | 100.0 |

3. Humidity was associated negatively with temperature to such a high degree that it was not possible to determine whether humidity might have some additional effect on fluid consumption in areas where high temperature and high humidity occur together.

4. Fluid intake per pound of body weight was highest among infants and decreased with age.

5. There were no substantial differences between boys and girls in the amount of fluid consumed per pound of body weight.

6. Under normal living conditions, water intake increased directly with increases in temperature.

A very interesting analysis of the percentage distribution of the kinds of fluid consumed (expressed as percentages of the total) is given in the table above.

These figures tend to indicate that drinking water is consumed at a more uniform rate than milk. The rates for drinking water (drinking water plus water-based beverages) are 43.4 and 47.6 per cent for children in Antioch and Brentwood, respectively, and similar rates for milk consumption are 47.9 and 39.9 per cent.

The findings in the report on climate and fluid intake were used by two of the authors—Galagan and Vermillion—to develop a method for determining optimum fluoride concentrations in drinking water. The paper, also published in the June 1957 issue of *Public Health Reports,* takes into account the effect of environmental temperature on water consumption among children. Using 5-year mean maximum temperatures for any locality, the corresponding recommended optimum fluoride concentrations are as follows:

| Temperature—°*F* | Fluoride—*ppm* |
|---|---|
| 50.0–53.7 | 1.2 |
| 53.8–58.3 | 1.1 |
| 58.4–63.8 | 1.0 |
| 63.9–70.6 | 0.9 |
| 70.7–79.2 | 0.8 |
| 79.3–90.5 | 0.7 |

# New Method for Fluoride Determination

**Floyd I. Brownley Jr. and Edgar E. Sellers**

*A contribution to the Journal by Floyd I. Brownley Jr., Prof., Dept. of Chemistry and Geology, Clemson College, Clemson, S.C., and Edgar E. Sellers, Union Bag and Paper Co., Savannah, Ga.*

THE development of a large number of methods for the analysis of fluorides was brought about by the early discovery that fluorides were present in almost all animal, vegetable, and mineral matter. In most instances the element occurred in only trace quantities, so colorimetric procedures have been extensively used, as gravimetric and volumetric techniques usually require larger concentrations of fluoride than occur naturally.

Many of the colorimetric methods of analysis utilize the formation of a colorless complex ion, formed by the combination of the fluoride ion and the ion of some heavy metal. If the heavy metal is first joined to some other substance to form a color lake, the fluoride ion will destroy the color lake by combining with the heavy metal. The destruction of this color lake, or bleaching, is proportional to the amount of fluoride present.

The first work using this principle was that of Fenton (*1*) in 1908, who utilized a sodium fluoride solution to determine titanium. Fenton titrated a standard sodium fluoride solution with an unknown titanium solution, the end point being determined by the use of dihydroxy maleic acid as an indicator. This acid formed a yellow complex with the titanium ions as soon as the metallic ions were in excess in the titrating solution. The reactions involved were: $Ti^{++++} + 6F^- \rightarrow TiF_6^{--}$; and at the endpoint, $Ti^{++++}$ + dihydroxy maleic acid → yellow complex of unknown structure.

A number of the colorimetric methods in use today are based on this work, and numerous modifications have been proposed. Other metals have been substituted for titanium, and complexing, or color-forming, agents such as hydrogen peroxide (*2*) and alizarin (*3*) have been used. Much of the literature of the analytical chemistry of fluorine is devoted to modifications made in order to apply the analysis to specific materials, as opposed to the introduction of new principles.

This paper reports upon the investigation into the use of ascorbic acid as a complexing agent, utilizing the abovementioned principle. Hines and Boltz (*4*) first reported the formation of a colored complex when ascorbic acid reacts with titanium. The interference of the fluoride ion with this complex was firmly established in the course of the present investigation.

## Apparatus and Reagents

Apparatus used in experiments included a colorimeter,* a pH meter,†

* The colorimeter used was the Spectronic 20, a product of Bausch & Lomb Optical Company, Rochester, N.Y.

† The pH meter was Model 18 of Coleman & Bell Company, Norwood, Ohio,

a 5-ml microburet, and volumetric flasks and pipets.

Titanium dioxide, $TiO_2$, is the most common, inexpensive source of $Ti^{++++}$ ions. Dissolving the oxide is extremely difficult, especially if it has been heated above 1,100°C. The following procedure should be used *:

Dissolve 15 g ammonium sulfate crystals in 25 ml concentrated sulfuric acid in a 250-ml beaker. Cool the solution to room temperature and add a weighed quantity of the $TiO_2$ (maximum 1 g). Cover the beaker with a watch glass and heat the mixture gently with frequent swirling of the beaker until a clear solution is obtained. Boiling should be avoided since it may result in precipitation of the $TiO_2$. Cool the solution to room temperature and carefully dilute to a volume of 100–200 ml, using small increments of cold water and frequent swirling of the beaker. This solution may be diluted further, but excessive dilution may result in hydrolysis and precipitation of the $TiO_2$.

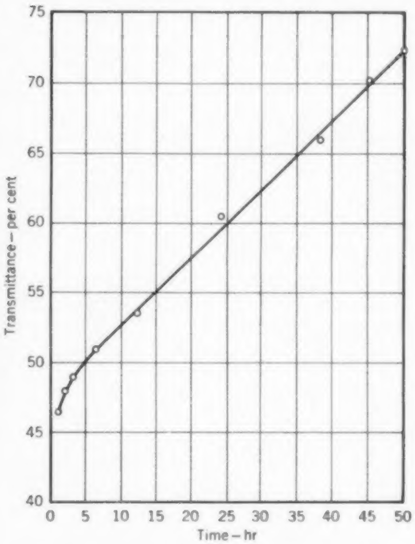


**Fig. 1. Decomposition of Ascorbic Acid Solution**

*Decomposition is shown by increased light transmission of an ascorbic acid–titanium complex.*

* The $TiO_2$ used in the experiment was obtained from E. I. du Pont de Nemours & Company, Wilmington, Del.

TABLE 1

*Effect of Stabilizing Agents on Ascorbic Acid**

| Elapsed Time *hr* | Transmittance—*per cent* | | |
|---|---|---|---|
| | Sodium Chloride | Thio Urea | Sodium Bisulfite |
| 24 | 61.0 | 62.0 | 60.0 |
| 48 | 59.5 | 61.0 | 61.0 |
| 72 | 60.5 | 57.0 | 61.5 |
| 96 | 60.0 | 58.5 | 61.0 |
| 120 | 51.5 | 56.5 | 60.5 |
| 144 | 52.5 | 58.5 | 59.5 |
| 168 | 54.5 | 56.5 | 59.5 |

* As shown by variation of light transmission of complexes of the acid.

USP ascorbic acid was used throughout this work and was stabilized with sodium bisulfite. Twenty grams of ascorbic acid and 8 g sodium bisulfite were dissolved in double distilled water, and diluted to 1 liter. This solution was kept refrigerated at 4°C. A brief discussion of the stabilization of ascorbic acid is included in a following section.

The fluoride solution used in these experiments was made by dissolving 0.0552 g of sodium fluoride per liter of solution. This gave an effective fluoride concentration of 25 ppm.

One of the difficulties attendant upon the use of ascorbic acid arises from the fact that the acid tends to break down into dehydro ascorbic acid. This degradation is fairly rapid at room temperature and in daylight. Figure 1 depicts the decomposition of ascorbic acid under ordinary room conditions.

Three substances were tested as stabilizing agents. These were a 30 per cent sodium chloride solution suggested by Vanesch and Ramezzana (*5*), the thio urea solution used by Kameran and Fearen (*6*), and the sodium bisulfite utilized in the work of Hines and Boltz (*4*). Results of the tests on these stabilizing agents (Table 1) show clearly the superior stabilizing effect of sodium bisulfite. Stability of the acid solution having been effected, the sodium bisulfite reagent was used in all experiments.

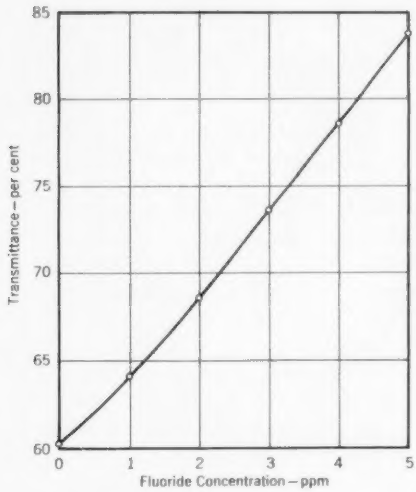


**Fig. 2. Effect of Fluoride Ion on Transmittance**

## Procedure

The following procedure for fluoride analysis is recommended:

1. Place in a 250-ml volumetric flask approximately 185 ml of water with no fluoride as a blank; in another flask, place 185 ml of water of unknown fluoride content.
2. Add to this solution 2 ml of glacial acetic acid and 3 ml of 5*N* sodium hydroxide.
3. Add 5 ml of ascorbic acid solution.
4. Add 1 ml of titanium solution.
5. Make up to volume.
6. After allowing a 5-min development time, read the transmittance in a colorimeter at 360 m$\mu$ compared to the blank at 100 per cent.

Data obtained from a series of experiments, using a complex of ascorbic acid and $Ti^{++++}$, carried out according to the above procedure were used to prepare a standard curve for fluoride analysis. This curve is shown in Fig. 2.

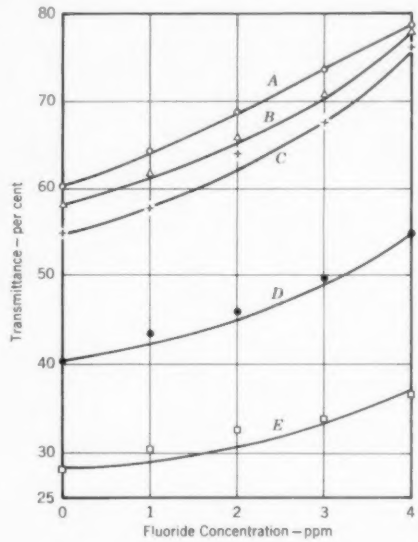


**Fig. 3. Interference of Iron on Fluoride Analysis**

*Concentrations of iron are represented by the following curves:* A, *0 ppm;* B, *0.5 ppm;* C, *1 ppm;* D, *5 ppm; and* E, *8 ppm.*

## Effect of Interfering Ions

One of the inherent difficulties in all fluoride determinations arises from the interference caused by other ions. It would be expected that the ions of the transition metals would interfere in this

type of procedure due to their ability to complex with the fluoride ion. Interference is particularly noticeable in the case of iron, aluminum, and magnesium.

Iron interferes in two ways with this determination. First, it absorbs light in the 360-m$\mu$ wavelength which is being used to measure the intensity of the lake itself. This obviously lowers transmission readings. Iron also complexes with the fluoride ion, and, in the higher concentration of fluoride, sharply decreases the slope of the curve. From Fig. 3, it can be seen that iron can be present to the extent of not over 1 ppm, as higher concentration causes too great a change in the slope of the curve.

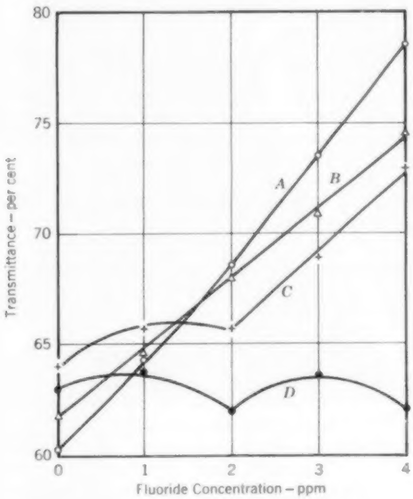


**Fig. 4. Interference of Aluminum on Fluoride Analysis**

*Concentrations of aluminum are represented by the following curves:* A, *0 ppm;* B, *0.5 ppm;* C, *1 ppm; and* D, *5 ppm.*

The interference caused by aluminum (Fig. 4) is undoubtedly due to the formation of the hexafluoro complex. The increase in color is due to lack of bleaching, as the fluoride is largely tied up in the complex.

Two anions had opposite effects on the lake. The phosphate effectively bleached the lake even in very low concentrations. The chloride ion (Fig. 5), however, had a reinforcing effect on the lake, as was noted by Cruz (*7*). No attempt was made to establish the cause of this behavior, but if a standard curve were developed with up to 50 ppm chloride, the linearity of the plot indicates that a determination of fluoride using it would be accurate.

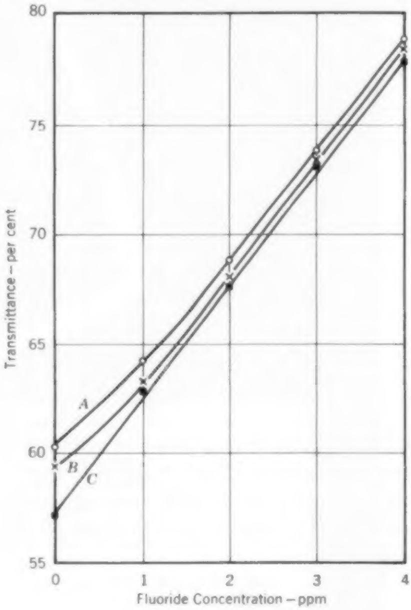


**Fig. 5. Interference of Chloride Ion on Fluoride Analysis**

*Concentrations of chloride ion are represented by the following curves:* A, *0 ppm;* B, *20 ppm; and* C, *100 ppm.*

Summation of the results of the tests made on interfering ions shows that the following maximum concentrations ap-

pear allowable: no aluminum, 1 ppm iron, 10 ppm phosphate, 50 ppm chloride, 5 ppm magnesium, and 15 ppm manganese.

## Evaluation

In order to ascertain the validity of the standard curve, a number of solutions of known concentrations were analyzed. Table 2 shows the results of these analyses. As can be seen from the table, this method of fluoride analysis compares well with existing methods, most of which are accurate to 0.1 ppm.

TABLE 2

*Evaluation of Analytical Method*

| Known Fluoride Concentration *ppm* | Found Fluoride Concentration *ppm* |
|---|---|
| 0.8 | 0.9 |
| 0.9 | 0.9 |
| 1.0 | 1.1 |
| 1.2 | 1.2 |
| 1.4 | 1.5 |
| 1.6 | 1.6 |
| 1.8 | 1.9 |
| 2.0 | 2.0 |
| 2.4 | 2.3 |
| 3.5 | 3.6 |
| 4.4 | 4.5 |

In summary, it may be said that a simple, accurate method has been developed for the determination of fluorides in water, using the ascorbic acid $Ti^{++++}$ complex. This method is as accurate and convenient as most of the methods in use today. It has the additional advantages of short development time and the use of easily available, easily stabilized reagents.

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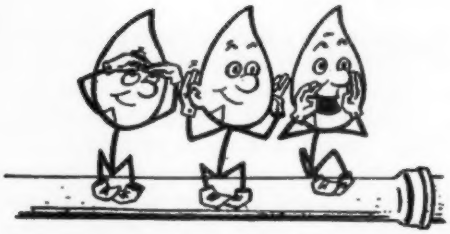

# Percolation and Runoff

**'All the Water You Need, When and Where You Need It!,'** our springtime slogan, should apparently be dropped dead—twice—come summer, when all water works efforts seemingly are bent toward stretching supply and system to make drought-ridden resources cover soaring demands. On the other hand, what better time to sell an adequate water system than when people are hot and thirsty? And what water worker wouldn't prefer providing all the water his customer needs rather than coaxing or cautioning or compelling him to conserve? Over the years the public has generally responded quite cooperatively to calls for conservation, but as the emergencies become annual, the enthusiasm or community spirit or sense of shame is likely to wane, if not worse. Worst, certainly, was the attitude of a resident of a Philadelphia suburb who last month wrote a sharp letter to the Philadelphia *Inquirer* in which he snapped:

An article yesterday in your paper with reference to possible "self-denial" curtailment of water in suburban Philadelphia set me to thinking. I intend to use as much water as I please, for what I please, whenever I please—so long as I pay my water bill.

As a public utility, the water companies are pledged to serve us with water. Part of our fee is to support any research program they need to keep abreast of our needs as public subscribers. Pools and other demands, such as new lawns needing nursing, etc., in our growing living areas should have been foreseen by the water authorities and proper action planned or taken.

Our country is experiencing the greatest period of prosperity in its history. There is nothing that Americans should not have, especially in utilities, if they are willing to pay for it. . . .

Actually, of course, our irate and antisocial friend has hit our nail right on the head. And if all water customers felt as he does and we could jettison our sense of social responsibility, we could make them happy—though perhaps poor—and ourselves less ulcerous. Unfortunately, customers tend to vary not only in their attitudes but in their resources, and a water utility has an obligation to serve them all. Even so, how much our friend "pleases" to use would undoubtedly be determined in fair measure by what he had to pay for his water and, by such devices as demand rates and reverse step rates, the customer who "pleases" can probably be made to pay, while those with more modest means

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and demands carry only the cost of a minimum system.

However pie-in-the-skyish "all the water you need" may sound—especially now in summer—it would seem a more inspiring and more publicly acceptable goal to work toward than "all the water we can manage to provide with the funds available, distributed equitably." That's the least we can do!

**Conservation,** which our previous comments may seem to have faulted, will always have a place, of course—even if we one day break crust on that pie in the sky. And one corner of that place will be reserved for fire protection use. That is not to suggest that we advocate letting fires burn themselves out to save water, but that we practice and preach fire prevention as the very best kind of water conservation. All of which is intended as a reminder that you have a direct interest and could well take an active part in the observance of Fire Prevention Week, next Oct. 6–12. Without going into the gory details of lives or money lost in the 2,000,000 fires that seared the US and Canada in 1956, you can certainly point to the 75 bil gal used from public water supplies to fight these fires as a good reason for your and your customers' concern. In short, unless you have water to burn, help prevent fires!

**Three training courses** will be given this fall by the Robert A. Taft Sanitary Engineering Center, USPHS, Cincinnati, Ohio. A course on the biology of polluted waters (Oct. 7–11) will provide training in the nature and use of aquatic organisms to measure and interpret water pollution. During a course on the bioassay of toxic wastes (Oct. 14–15), trainees will study the effects of the increasing quantity, variety, and complexity of wastes on fishes and other organisms—information which will help in the evaluation of toxicity and the institution of suitable management practices. A course on advanced training in detection and control of algae and other organisms which may interfere with the operation of water supply reservoirs, treatment plants, and distribution systems will be held Nov. 4–8. Applicants should have some previous training in the analysis of plankton or experience in the operation of water treatment plants. Emphasis will be on laboratory practices in identification and counting of plankton.

The three courses are available to personnel in industry and regulatory agencies; in state, county, and municipal health departments; in fish and game departments; in water supply and water pollution agencies; and in colleges, universities, and research organizations. Application blanks and additional information may be obtained by writing to the Robert A. Taft Sanitary Engineering Center, 4676 Columbia Pkwy., Cincinnati 26, Ohio.

**B. A. Poole** has taken office as chairman of the Ohio River Valley Water Sanitation Commission, succeeding Kenneth M. Lloyd. Chairman Poole, a sanitary engineering administrator of wide experience (including service as director of the Bureau of Environmental Sanitation, Indiana Board of Health), has been an Orsanco commissioner since 1948, the year in which the interstate agency was formed.

Mr. Poole is also the new chairman of the Joint Committee for the Advancement of Sanitary Engineering, an organization in which AWWA actively participates.

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**That East meets West** will not come as news to those who attended AWWA's Atlantic City Conference last May. But for the benefit of readers unable to be present, we publish the following excerpt from an account by Correspondent Ishibashi of the Japanese Water & Sewage Works Operators Assn. newspaper:

**AWWA総会出席記**

在米 石橋多門

アメリカ水道協会の第七十七回会は五月十二日から十七日までNew Jersey州のAtlantic Cityで開催された。私は丁度フイラデルフイア市に九日—十一日と滞在した後、この大会に出席する機会をもつた。

フイラデルフイアから飛行機で僅かに二〇分飛上つたと思つたら

延々数キロメートルも伸び、これに面して豪しやかなホテルや飲食店土産物や、娯楽場、映画館が櫛比している。今は丁度季節外れで人も少いが、夏ともなるとその繁盛ぶりは大したものだろう。このBoard Walkを流行の先端をゆくヤンキーボーイ、ヤンキーガールがシャナリシャナリと漫歩する

建物の外観も馬鹿でかいが中へ入つてすぐの大ホールには何と八〇米に一五〇米の床の広さである大音楽会、大集会、アイススケートはおろかインドアのサツカーがやれるというから相当のもの、しかも観覧席が三万五千人入れるわけである。有名な全米の美人コンクールもこの場所で行われる。こ

The issue from which the above was taken also contained an instalment of a report on stream pollution law and other matters written by a Mr. "C. W. Ku-ra-ssen." It doesn't take much knowledge of the Japanese language to recognize that as the nom de plume of C. W. Klassen, chief sanitary engineer of the Illinois Dept. of Public Health. The report is one that he submitted to the Japanese government. *Omedetō gozaimasu, Kurassen-san!*

**A rainy day** that really required some saving found Melvin Brogdon, water works superintendent at Monon, Ind., awake to his responsibilities at the wee hour of three on the morning of Jun. 17. His predawn activity would undoubtedly have gone unnoticed as being all in the day's work had not the state health department learned of it. The result was this commendatory letter from State Health Commissioner A. C. Offutt to the president of Monon's town board of trustees:

Rains of excessive intensity, falling on a two- or three-county area north of Lafayette, caused considerable damage by local flooding on Jun. 17, 1957. Monon was in the middle of this area and would have suffered more inconvenience, damage, and an acute public health emergency if your water works superintendent had been less diligent and efficient in the discharge of his obligations.

Our field men who visited your community during the high water report that Melvin Brogdon went to City Hall to check his pumps and wells at 3 AM during the rainstorm. He found the basement rooms were flooding but was able to save his equipment and to keep the wells from being contaminated, by immediate installation of sump pumps.

As a result of his prompt action, the citizens of Monon were saved the nuisance of carrying water for individual use and of boiling that water used for drinking. As State Health Commissioner, I would like to commend you on the efficiency of this civil employee.

Few, of course, are the water superintendents unfamiliar with the wee

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hours of many mornings, but fewer still are the customers who appreciate that fact. Thus, we are happy about the commissioner's letter not because its description of Melvin's matutinal manipulations at Monon reports anything that we wouldn't expect, but because it may help to make such acts a little less unexpected among water customers.

**Speaking of service,** 595 years of it by 29 employees is now being recognized at the Alliance, Ohio, Department of Water & Sewage by the awarding of Willing Water service pins (shown twice diameter below). With


service periods that range from 5 to 55 years and average more than 20, these employees, too, provide a record of water works superservice about which customers ought to know. Like weehourism, longservicism in the water works field is so common that it too often goes unnoticed, a situation which Don Heffelfinger, superintendent at Alliance, and Willing Water, superineverything everywhere, have now moved to correct. The new service pin has been designed to permit changing the utility name and the years of service, thus to make it available to other AWWA longserviciters.*

* A catalog of Willing Water service pins and other items will be mailed to all members with the next issue of *Willing Water.*

**Sea water contamination** of the well water of Suffolk County, Long Island, N.Y., has taken place in only a few isolated, near-shore wells, according to a US Geological Survey report recently released. Chloride contamination of some well waters is traceable also to fertilizers, sewage, industrial wastes, and salts used for highway maintenance.

The excellent cooling properties of the ground water of Suffolk County are indicated by measurements of water temperature tabulated and discussed in the report. These range from 50° to 55°F for water in wells less than 300 ft deep and from 50.4° to 64°F for water in deeper wells.

Among other conclusions, the report emphasizes the fact that contaminants other than sea water can cause above-normal concentration of chloride in ground water and that any suspected sea water encroachment must be appraised accordingly. In Suffolk County, an area of 920 sq miles, more than 20 bil gal of ground water is pumped annually for industry, public and domestic supply, and irrigation. Sea water that borders three sides of the county is a potential threat to the water supply, and a constant monitoring program is in effect.

Copies of the report, entitled "Chloride Concentration and Temperature of Water From Wells in Suffolk County, Long Island, N.Y., 1928–53," by J. F. Hoffman and S. J. Spiegel, may be examined at the offices of the USGS in Mineola, N.Y., and Washington, D.C.; at the Suffolk County Water Authority, Brightwaters, N.Y.; the Suffolk County Dept. of Highways, Port Jefferson, N.Y.; and the New York State Water Power & Control Commission, Jamaica, N.Y., and Albany, N.Y.

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**From Voroshilov to Usurisky,** *from Pervaya Rechka to Egersheld, wherever the Vladivostok line goes . . .* there, too, these days goes water, if only to help meet the freight quota of the Soviet Union's "annual plan" for railroads. According to the Vladivostok line's official newspaper, it was one Comrade Vorobov, an exceptionally ingenious executive of the line, who discovered water in the winter of 1955, when his section was in danger of going under its monthly quota for liquid deliveries. Then it was that he conceived the idea of loading 50 tank cars with Voroshilov water and shipping them to Usurisky to meet his quota and keep his job. That water froze was something Vorobov had apparently not yet discovered, but the Central Committee must have determined that it did not freeze until after arrival, for the liquid quota was considered filled, and the fact that it took a month to chisel the ice out of the tank cars at Usurisky must have meant that that section was below quota on its maintenance, for even in Russian railroading it would seem that at least one of the crew must sometime have discovered heat. At any rate, friend Vorobov lived to think again.

His second thought came in May of this year, when the quota was threatened again. By then Vorobov's education in and appreciation of water had advanced tremendously. Thus, recognizing that water would not freeze in summer and having determined that it would run downhill, he loaded 150 tank cars from a water main at Pervaya Rechka and hauled it to Egersheld, where he planned to return it to the main and let it flow back again—giving him a permanent, at least summertime, solution to his quota problem. Unfortunately, the train crew experienced some difficulty in getting the water out of the cars and into the main at Egersheld, so that the entire load was released on the tracks, washing out the roadbed completely. That this occasioned some "slight and unfortunate" delays on the line was of minor consequence; the quota was maintained and, as a matter of fact, a new maintenance record was undoubtedly established.

With the publication of these feats of ingenuity in a Soviet Union newspaper, Comrade Vorobov will undoubtedly be in line for a Malenkov medal if he doesn't first help his quota in person on a train headed for the border. For his discovery of a heretofore unthought of, if unthinkable, use of water, however, AWWA might well vote a furbelow for Vorobov, even if . . . *the man is a two-face!*

**Do-it-yourselfishness** has reached a point now where a homeowner quails at nothing. The recent story of a toilet block in Park Forest, Ill., was billed by the United Press as a story of "heroism in the suburbs," which it certainly was, but more than that it was a well told story and a sign of the times:

It involves a woman. She has five children, one of whom flushed a toy building block down the toilet. Father was out of town. Mother couldn't get a plumber because it was Sunday. So she turned off the water and somehow removed the toilet. But the block wouldn't budge despite her efforts. She thought maybe water pressure would free it. But she had turned off the water. Then she dammed the toilet outlet with a towel, turned the water on and moved the toilet out to the backyard.

She had just started the job of freeing the trapped block with the garden hose when another of the children yelled:

(*Continued on page 54 P&R*)

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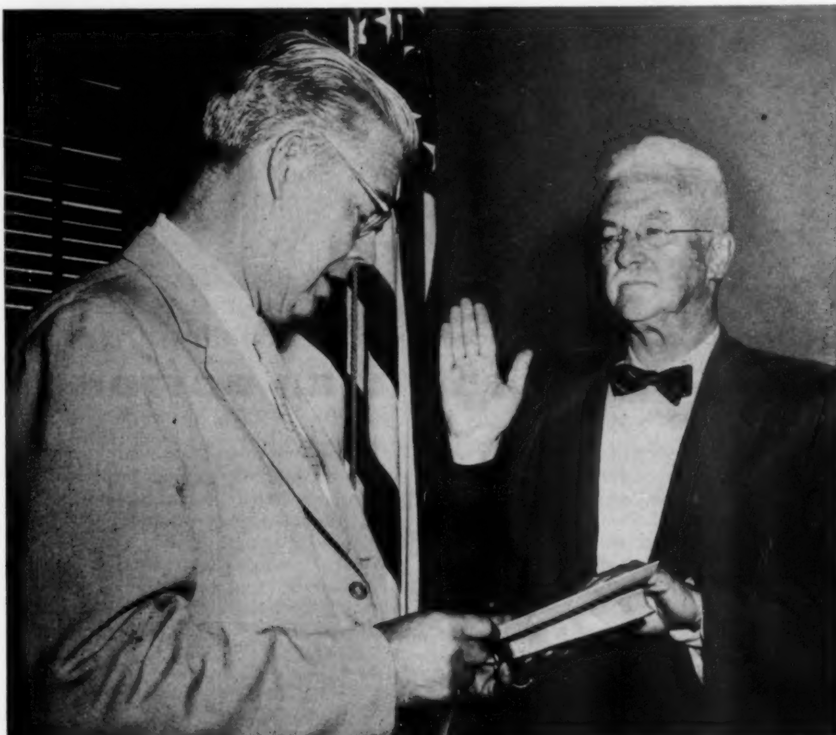
"Mommie, it's getting pretty wet in here!" The towel had not held and a miniature "Old Faithful" was spouting in the bathroom. The woman turned off the water again. She put the toilet in a little red wagon and wheeled it across the street to the home of a neighbor, where she asked for and was granted permission to use the hose and some water.

Pressure did not free the block, but the sight of a woman hauling a toilet in a little red wagon across the street trailed by five children brought out many interested neighbors. These neighbors offered many suggestions, but all fell short. Finally, the husband came home. He knew where there was a hardware store open. He put the toilet in the car and took it to the hardware store. The hardware man, a father himself, freed the block by sawing it in half. The toilet was brought home and reinstalled.

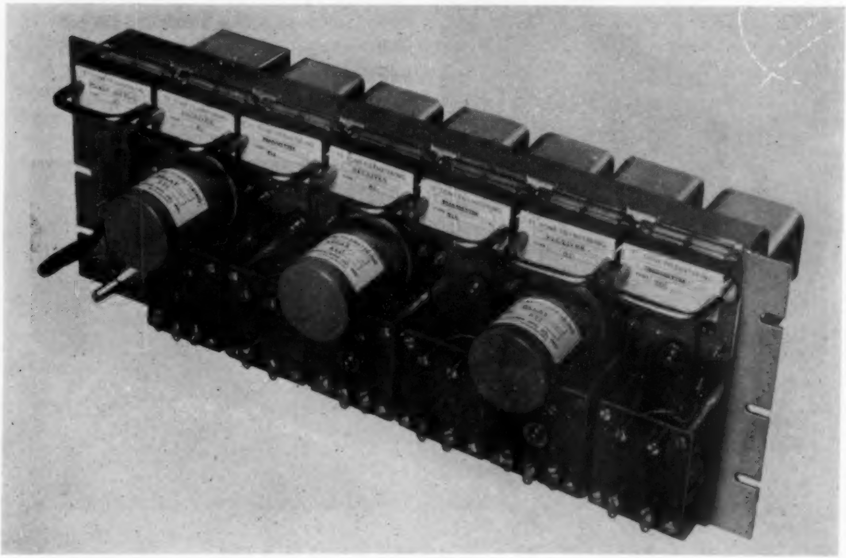
An hour later there was another block in it.



**Charles K. Bassett, vice-president and secretary, Buffalo Meter Co., Buffalo, N.Y., takes the oath as director of the Water & Sewerage Industry & Utilities Div. of the Business & Defense Services Administration, US Dept. of Commerce. Swearing him in is BDSA Administrator H. B. McCoy.**

*(Continued on page 56 P&R)*

(*Continued from page 54 P&R*)



**Centralized supervisory control systems** can now utilize the advantages of transistorized audio-tone transmission. Up to eighteen functions, telemetering and controlling, may be transmitted by a single pair of private or leased wires, carrier current, radio, or microwave. Ease of assembly, interchangeability, installation, and system expansion, as well as lower power and maintenance costs, are claimed for the compact, completely transistorized, "plug-in" design of the power supply, transmitters, and receivers. These units were developed in conjunction with, and manufactured by, Warren Mfg. Co., exclusively for Builders-Providence, Inc., a division of B-I-F Industries, Inc., 345 Harris Ave., Providence, R.I. Details can be obtained from Sup. Bul. 240-P4, issued by Builders-Providence.

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**Annual awards** for best operated water treatment plants have been announced by the Florida Board of Health for 1956–57. Treatment categories (various population classes) and recipients are: lime-soda softening—George Solberg (superintendent, Alexander Orr Plant, Miami), E. C. Shreve Jr. (superintendent, Ocala), John B. Sellers (superintendent, Vero Beach), H. B. Stroud (superintendent, Myrtle Grove Subdivision); filtration—Lynn D. Yoder (superintendent, Clewiston); primary treatment—Edward T. Helms (superintendent, Winter Haven), Jack S. Whitney (superintendent, West Coral Way Area).

**Walther H. Feldmann** has been elected president of Worthington Corp., Harrison, N.J., succeeding Edwin J. Schwanhausser, who becomes vice-chairman of the board. Mr. Feldmann has been executive vice-president since 1955.

**Neptune Meter Co.** has purchased a four-level, square-block building in Long Island City, N.Y., formerly occupied by Columbia Broadcasting System. The acquisition, part of the firm's expansion and diversification program, will be utilized by the Liquid Meter Div. for manufacturing and assembly operations.

**J. B. Miller (back row, left), chief, Water Supply & Treatment Sec., Florida Board of Health, Jacksonville, with award winners Sellers, Stroud, and Solberg; front row—Yoder, Shreve, Helms, and Whitney. See story above.**

(Continued on page 88 P&R)

# *Rate Yourself as a* METERologist...

**CHECK HERE**

- ☐ Do you believe in setting water meters so that they are most available for quick and easy reading?
- ☐ Do you provide installations which put meters in the proper position and protect them from dirt and damage?
- ☐ Are your meters connected into the line so that changing can be quick and trouble-free?
- ☐ Do you test meters periodically and maintain them for maximum accuracy?

**If you have checked all four you probably use Ford equipment. Don't be discouraged if your grade is off a little; the easy first step toward improving it is to send for a FORD CATALOG. IT'S FREE.**

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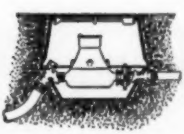
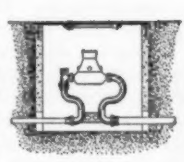


**YOKE BOX**

For shallow services the Yokebox provides protection to keep meter clean, easy to read and easy to change.

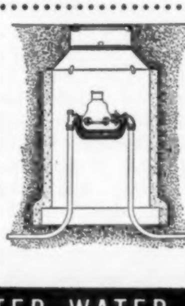


**COPPERSETTER**

A complete meter mounting that brings the meter up for easy reading and changing. Holds service line permanently connected.

**COPPERHORN**

Ideal setting for most basements with vertical service lines. Often saves more than its cost in pipe fittings.



**DOUBLE LID SETTING**

Provides maximum frost protection in cold climates. The Yoke holds risers permanently braced and connected for easy meter changing.

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# Condensation

**Key:** In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

## CHEMICAL FEEDING, CONDITIONING & SEDIMENTATION

**Certain Aspects of Flocculation as Applied to Water and Sewage Purification.** A. R. Ritchie. Thesis, University of London, 1955. Results are given of expts. on effect of stirring on flocculation in water and sewage treatment. In these studies, "coagulation" is used to describe initial aggregation of colloidal particles until they become visible to naked eye, and "flocculation" is used to describe building up of flocs from these just-visible aggregates. Mechanism of coagulation and flocculation is discussed. In studying effect of any variable factor on coagulation and flocculation, method for assessing progress of reaction is necessary. Existing methods for measurement of flocculation by nonoptical and optical methods are reviewed, and description is given of development of app. for following course of flocculation by measuring transmittancy. It is thought that optical measurement is not satisfactory method of measuring absolute floc size, but can be used for comparative purposes, and measurement of change of transmittancy is useful as means of recording progress of flocculation. In expts. on effect of veloc. gradient on flocculation, Camp and Stein's theory was examined both theoretically and experimentally and was found to be satisfactory, with certain modifications. Modified theory can be applied to predict min. time in which floc of particular size can be built up, and this is suggested as criterion by which to judge efficiency of machinery used to promote flocculation. Flow pattern which stirring machinery should, ideally, produce can also be established from theory. Results of expts. indicated that, other things being equal, size of floc built up in suspension is inversely proportional to max. veloc. gradient to which it is subjected. Phys. effects of temp. are small and probably result from changed viscosity of water. Rate of formation of floc is proportional to veloc. gradient, but only as long as this does not exceed certain value depending on suspension, and to root mean square veloc. gradient as long as max. veloc. gradient at any point in suspension does not exceed that same value. For any given suspension, there is min. time of flocculation, and ratio of this to time actually required by particular machine provides measure of flocculating efficiency of machine. Ideal stirring arrangement for flocculation is one in which veloc. gradient is uniform at all points in stirring chamber. In cases where it is applicable, where floc is not recirculating, taper mixing may be used to reduce time of flocculation. In appendix, account is given of expts. to find method of measuring floc density; these were not successful. Illustrations of app. and graphs showing results of expts. are included, and bibliography of 67 references is appended. —*WPA*

**Stabilization of Water.** C. Callaghan. Offic. Bul. N. Dakota Wtr. Wks. Conf., **24**:3 ('56). In paper presented at 27th Annual Convention of North Dakota Water and Sewage Works Conference in Williston, author gives his views on stabilization of water. In well waters, calcium, magnesium, and soluble iron are either removed from water or stabilized by addition of chlorine and phosphates. Partially softened waters create problem in that they must be stabilized before entering mains; a chem. stabilizer, usually polyphosphate or blend of phosphates, is most commonly used. Factors influencing corrosivity of water are discussed. Author stresses importance of stability index.—*WPA*

**The Application of Granular Active Carbon for Dechlorination of Water Supplies.** V. Magee. Proc. Soc. Wtr. Treatm. Exam.,

(*Continued on page 72 P&R*)

# IT SEEMS MOST
# *NEW* ROCKWELL SEALED

(*Continued from page 68 P&R*)

**5**:17 ('56). Author gives summarized account of recently completed research project on dechlorination of water by active carbon. Basic design considerations for active carbon filter for dechlorination are outlined showing derivation of design eq. embracing concn. of chlorine, rate of flow of water, and filter bed dimensions. Exptl. technique, app. used, and data obtained in investigation of reaction mechanism and carbon filter efficiency are described. It was concluded that in new carbon filter reaction changes from initial adsorption of hypochlorous acid molecules onto carbon surface to catalytic decompn. of adsorbed molecules into hydrogen and chloride ions and nascent oxygen. Based on accepted design eq., efficiency of dechlorination process, and influence of variable factors, grade and size of active carbon granules, pH value of water, and temp., were examined. Application of process on board ship and at land waterworks is described. Discussion which followed reading of paper is reported.—*WPA*

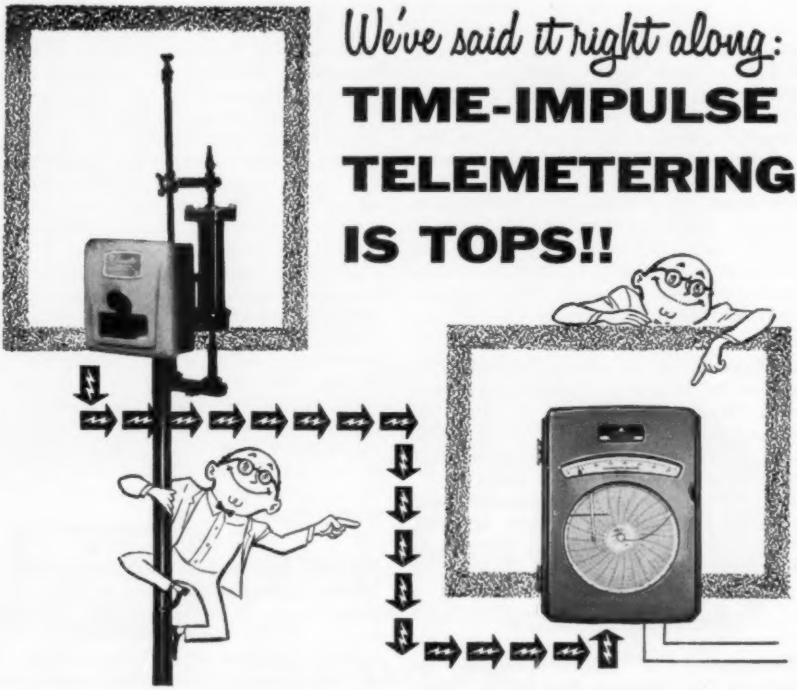
**Carbon Slurry Storage and Feeding at Northeast Station, Detroit, Mich.** M. A. Garnell. Taste Odor Control J., **23**:1 ('57). Mechanical equipt. for slurrying activated C and feeding C slurry for treatment of domestic water is described.—*CA*

**Contact Clarification—A New Method of Purifying Drinking Water.** S. S. Bliokh, A. M. Perlina, & N. L. Kozlova. Gigiena i Sanit. (USSR), **22**:70 ('57). In contact clarification $H_2O$ is brought into bottom of gravel-sand bed and flows out top. Coagulant is added immediately before entering app. Head necessary to maintain flow does not rise rapidly, and good deal of coagulation takes place on surfaces of larger particles at bottom. Well constructed app. will match ordinary filter in qual. of $H_2O$ produced.—*CA*

**Polyelectrolytes as Coagulants and Coagulation Aids.** C. E. Johnson. Ind. Eng. Chem., **48**:1080 ('56). Investigation was made in labs. of National Aluminate Corp., Chicago, on behavior of polyelectrolytes as coagulants and coagulant aids, in comparison with other commonly used coagulants, for treatment of low turbidity water, lime-soda and phosphate-softened waters, and copper mine and phosphate mine

(*Continued on page 74 P&R*)

# We've said it right along: TIME-IMPULSE TELEMETERING IS TOPS!!



## ...AND YOU'VE SAID IT TOO...WITH YOUR ORDERS!!

**In Builders Chronoflo Telemetering Systems:** The transmitting and receiving reactions depend only upon the *positively* controlled duration of regular electric circuit closures and *nothing* more.

*The Telemeter is a pure, *positive-action* positioning system.

- It *does not* have to *translate* units of electric measurement into terms of rate of flow or other factors measured.
- It requires *no* relatively delicate electric components.
- It *doesn't employ* a series of contact rods "shorted out" by step-by-step action of rising mercury.
- It is *not affected* by normally encountered induced voltages.
- Receiver *accuracy not affected* by room temperature, line pressure, duration of "down time", and similar factors.

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METERS FEEDERS CONTROLS

(*Continued from page 72 P&R*)

waste waters. Coagulating effects of specified amts. of alum, sodium aluminate, starch, saponitic clay, and of polycationic and polyanionic material on waters are shown in photographs, from which it can be seen that on all but low turbidity water, 2 polymeric coagulants gave best results. With low turbidity water, use of polycationic materials as coagulant aid in conjunction with alum or saponitic clay, only coagulants having any effect when used singly, resulted in greatly improved coagulation. Coagulating behavior of polyelectrolytes is discussed.—*WPA*

**The Experiments of Ferric Chloride Application for Water Coagulation of Novosibirsk Water Supply.** E. S. Abazaev. Vodosnabzhenie i Sanit. Tekh. (USSR), No. 6 ('56). Successive addn. of milk of lime, $FeCl_3$, and $Al_2(SO_4)_3$ to water at 1°, contg. 1600 mg/l suspended particles and having 1.5 mg/l alfl., ameliorates speed of filtration and increases 2 times duration of filter operation.—*CA*

## BACTERIOLOGY

**Differentiation of Microorganisms by Means of the Infrared Spectra of Their Acetone Extracts.** R. T. O'Connor, E. R. McCall, & E. F. DuPre. J. Bacteriol., **73**:303 ('57). Method for differentiation of microorganisms by comparing infrared spectra of aqueous acetone extracts instead of spectra of entire organisms is described. Procedure consists of 6 independent steps: [1] careful culture of the microorganisms on same selected growth medium and under standardized growth conditions, [2] cell disintegration with mechanical grinder, [3] acetone extraction under controlled conditions, [4] prepn. of smears of microorganism extract on silver chloride discs, [5] measurement of infrared absorption spectra of organisms on silver chloride discs against plate containing no extract, and [6] comparison of spectra of acetone extract with spectra of acetone extracts of known bacteria. Details of each step in proposed procedure reproducibility of entire method, and advantages of acetone extraction procedure over spectra of entire organism are described. Further advantages of successive extraction with series of small number of carefully selected solvents are cited.—*PHEA*

**Estimation of Bacterial Density of Water-Samples. Methods of Attaining International Comparability.** S. Swaroop. Bul. World Health Organization, **14**:1089 ('56). Statistical problems involved in estn. of bact. density of water samples by so-called "dilution" method are reviewed, and some ways of arriving at international comparability of ests. are suggested. It is emphasized that aim of diln. test should be not only to det. "MPN" of organisms in sample, but also to specify accuracy of estn. by providing 2 confidence limits within which true bact. density will lie. Diln. schemes recommended for routine testing of water qual., for more precise estns. of number of organisms in water supply before and after treatment, at different times, or at different levels, and for tests of heavily pold. supplies are described, and factors affecting frequency with which sampling should be carried out are briefly discussed.—*PHEA*

**Further Studies on Coliform Tests on Water Carried at 30°C and at 39°C.** S. D. Hendriksen. Acta Pathol. Microbiol. Scand., **38**:101 ('56). Follow-up of Hendriksen's previous study, using coliform test on water samples, in mannitol broth cultures at 30°C and subcultures in lactose broth at 39°C. These seemed to give more reliable results than cultures in lactose broth at 37°C. Rate of detection of coliforms was higher by new method than by previous one. New technique gave higher rate of recovery of *Escherichia coli* and correspondingly more effective elimn. of organisms of questionable significance.—*PHEA*

**Role of Oxygen in Modifying Radiosensitivity of *Esch. Coli* B.** T. Alper & P. H. Flanders. Nature (London), **178**: 978 ('56). Authors describe how it was found during X-ray expts. that presence of even 1$\mu$ mole of oxygen per liter increased radiosensitivity of *Esch. coli* B. Expts. were then made to det. effect of varying concns. of oxygen upon *Esch. coli* B. Relationship between radiosensitivity and oxygen concn. was detd. by plotting survival curves for *Esch. coli* B under nitrogen, oxygen and range of nitrogen-oxygen mixtures. Eq. was evolved which would give relationship between radiosensitivity and oxygen tension in other materials. Authors

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set out 3 hypotheses which might account for oxygen effect. These are $HO_2$ radical hypothesis and respiratory enzyme hypothesis, both of which are thought to be unlikely solns., or direct-effect hypothesis put forward by themselves. This suggests that primary action of radiation may prevent cell multiplication by ionizing vital target structure or molecule. If oxygen is present it will react with ionized molecule and reduce probability of restoration.—*WPA*

**Chelation as a Method for Maintaining the Coliform Index of Water Samples.** E. L. Shipe & A. Fields. Public Health Repts., **71**:974 ('56). Authors describe expts. made using chelating agent, ethylenediamine tetraacetic acid (EDTA), with samples of various waters inoculated with *Escherichia coli,* to det. effect of EDTA on rate of decrease in viable cells. Expts. were made using *Esch. coli* in water contg. copper or zinc, buffered distd. water and deionized water. It was found that EDTA materially reduces rate of decrease of *Esch. coli* cells, and therefore authors suggest that for periods up to 24 hr, chelating agents would be of value in maintaining coliform index near level existing at time the sample is taken. Results of various expts. described are given in graphs.—*WPA*

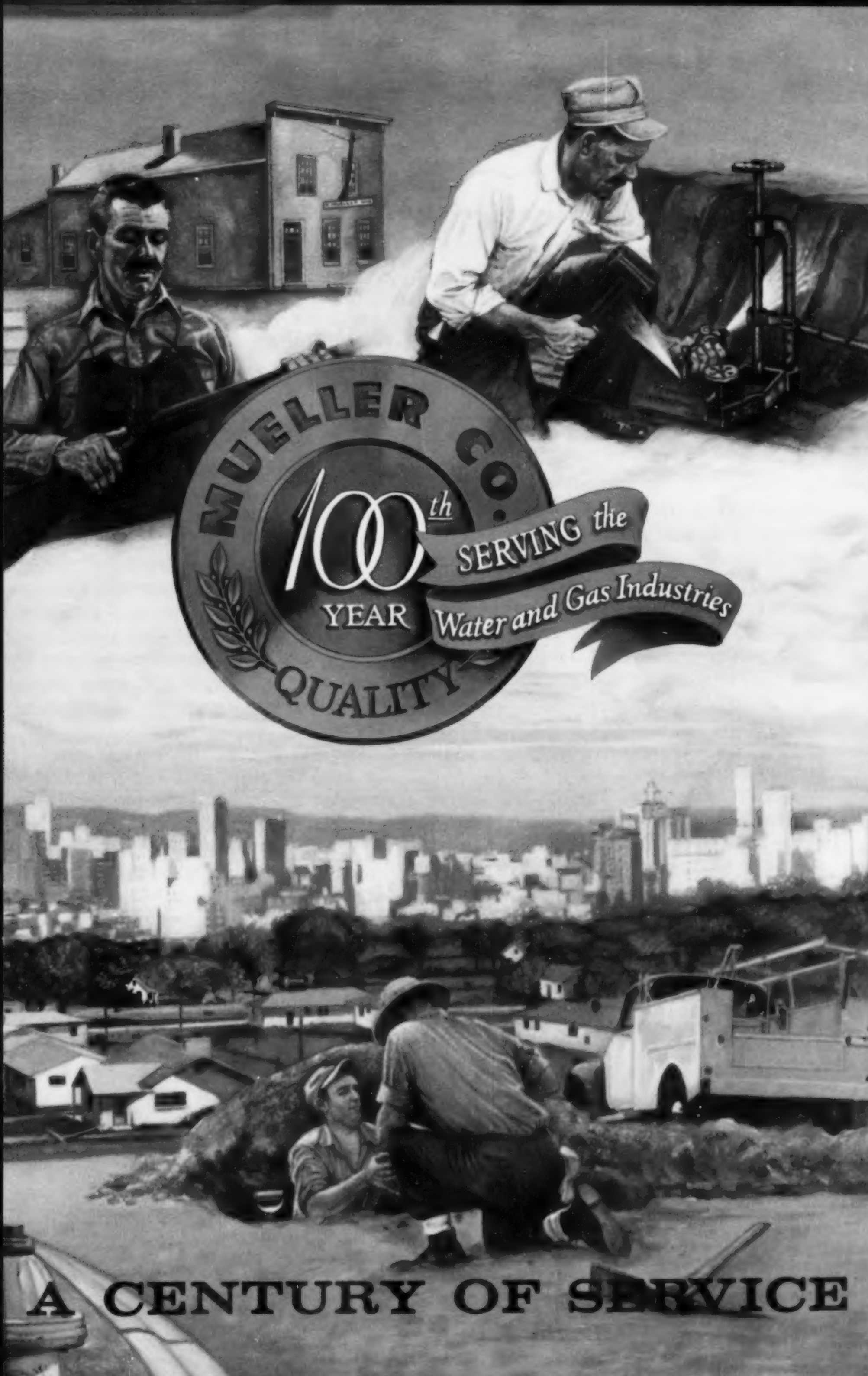
**A Comparison of the Bactericidal Activity of Ozone and Chlorine against *Escherichia coli* at 1°.** R. H. Fetner & R. S. Ingols. J. Gen. Microbiol., **15**:381 ('56). Comparative study of bactericidal activity of ozone and chlorine is reported in which suspensions of *Escherichia coli* were treated with stable solns. of ozone at 1°C and pH 2 and with chlorine solns. at 1°C and pH 6.8; various concns. and contact periods were used. Ozone concns. were detd. by ferrous-ferric technique and chlorine concns. were detd. iodometrically. Results are shown in tables and graphs. Lethal concn. of ozone, under exptl. conditions, was found to be between 0.4 and 0.5 mg/l, and was independent of contact time greater than 1 min. Chlorine at concn. of 0.25–0.30 mg/l effected same percentage kill in 1–10 min. Whereas bactericidal activity of chlorine increased with concn. and period of contact, ozone was found to be ineffective below critical concn. 0.4–0.5 mg/l, at which concn. it effected total bact. destruction within 1 min; this latter fact was emphasized by measurement of oxidation-reduction potential of buffered bact. suspensions after addition of various amts. of ozone.—*WPA*

**Evaluation of Methods for Reporting Coliform Density.** E. S. Hopkins & K. H. Schamberger. Am. J. Public Health, **46**: 987 ('56). Authors show, by use of tables, that more accurate values are obtained for coliform density of pold. waters if geometric mean (average of logarithmic values) is calcd. rather than arithmetic mean for daily figures obtained from counts. By this method abnormally high or low figures are equalized, which is not case when arithmetic mean, or average, is taken, and it has been found that geometric mean figure is relatively close to figures calcd. from frequency distr. data and to observed median from an array.—*WPA*

**Mannitol Bile Broth for the Identification of Faecal Streptococci.** J. A. Rycroft. Monthly Bul. Minist. Health Lab. Serv., **15**:197 ('56). Properties that distinguish faecal streptococci are summarized. Mannitol bile broth is described for routine identification of faecal streptococci. With this medium it is possible to test for mannitol fermentation, growth in presence of bile salt, growth at 44°C and formation of Group D carbohydrate (in glucose broth at 37°C). It is suggested that medium be used as screening test for $\beta$-haemolytic strains, and for rapid identification of $\alpha$- or nonhaemolytic strains of streptococci.—*WPA*

**A Rapid Method for the Identification of *Salmonella* Species.** G. N. Cooper. J. Pathol. Bacteriol. (Br.), **72**:39 ('56). Rapid method for identification of *Salmonella* has been devised, based on identification of flagellar antigens of *Salmonella* cultures through ability of homologous diphasic 'H' antisera to inhibit swarming growth through a semisolid agar. Clear plaque-like zone of inhibition is observed at site on which reacting serum is placed. Method permits identification of *Salmonella* species within 3 days of their isolation, but it is stressed that specific diagnosis by this method should always be confirmed by usual serological methods.—*WPA*

(*Continued on page 77 P&R*)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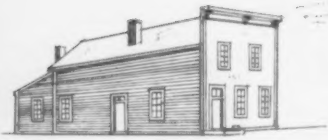
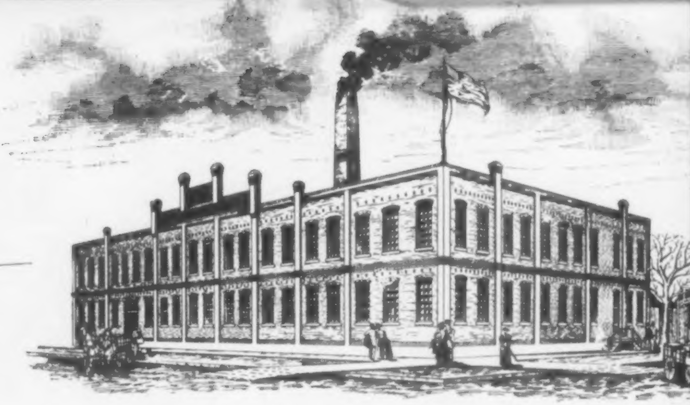




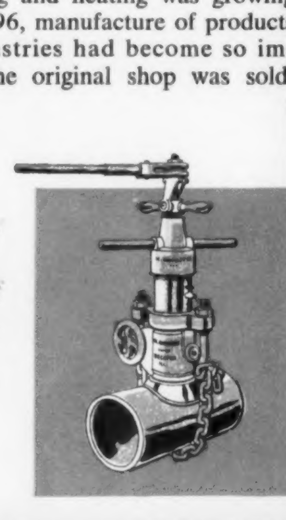
# ONE HUNDRED YEARS AGO...

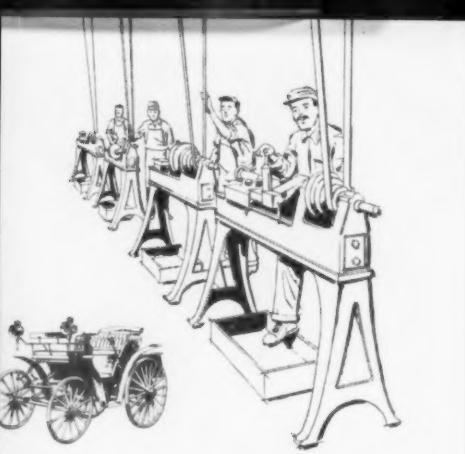
In the fall of 1857, Hieronymus Mueller came to Decatur, Illinois. Opposite the town's livery stable, he opened a one-man shop, making guns and tools and repairing anything mechanical. Mueller's inventive mind and insistence on perfection gained many customers, and the shop prospered.

In 1871, Mueller was appointed plumber for the city of Decatur. In those days, the comfort and convenience of running water in the home was possible only after a cumbersome, troublesome service connection was made to the main. The plumber drilled a hole, almost through the main, with a crow and ratchet. A corporation "drive" stop was inserted and was secured in the main by a sharp blow with a sledge—if the blow hit true. If the blow missed, the plumber was drenched and the ditch filled with water, necessitating an interruption in service to all customers while pressure was reduced and the connection made.

Mueller went to work to devise a more efficient method. After weeks of experimenting, he devised the original "B" Tapping Machine, permitting plumbers to drill through the main and insert a corporation stop under pressure, without loss of water. A vital need of an expanding industry had been answered—the first of many answers for gas and water problems through a century of progress.

The "B" Machine established Mueller in the manufacturing field and a new, three-story factory replaced the one-room shop. Sixteen men kept working full time to turn out an annual volume of $25,000 worth of water and gas distribution products. The demand for the luxury of running water and gas for cooking and heating was growing rapidly. By 1896, manufacture of products for these industries had become so important that the original shop was sold.





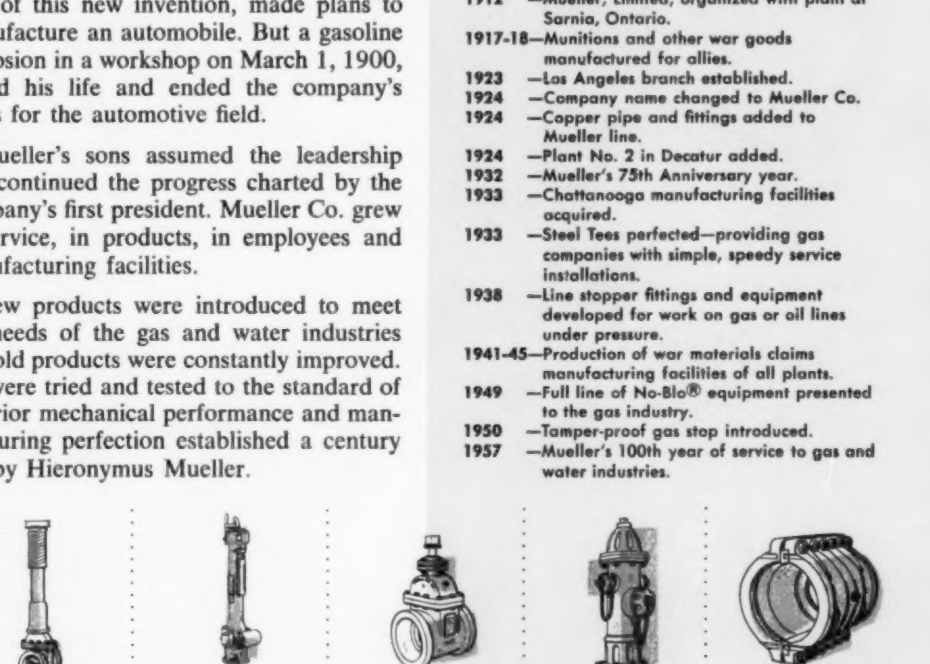
It was in this era that Mueller became nterested in the new horseless carriage. He eveloped several innovations for the utomobile, including variable-speed transnission, body suspension, water-cooling adiators, spark plugs and breaker circuit. ome of his original, patented ideas are still n use. Hieronymus, convinced of the fuure of this new invention, made plans to nanufacture an automobile. But a gasoline xplosion in a workshop on March 1, 1900, nded his life and ended the company's lans for the automotive field.

Mueller's sons assumed the leadership nd continued the progress charted by the ompany's first president. Mueller Co. grew n service, in products, in employees and nanufacturing facilities.

New products were introduced to meet he needs of the gas and water industries nd old products were constantly improved. All were tried and tested to the standard of uperior mechanical performance and manfacturing perfection established a century go by Hieronymus Mueller.

## MILESTONES OF PROGRESS

| | |
|---|---|
| 1857 | —Hieronymus Mueller opens general machining and manufacturing shop in Decatur. |
| 1871 | --Mueller appointed city plumber. |
| 1872 | —First tapping machine invented. |
| 1872 | —New Mueller factory erected. |
| 1882 | —Invented water pressure regulator. |
| 1882 | —Mueller joins AWWA—one of the first five members. |
| 1885 | —Large scale manufacturing of brass goods started. |
| 1893 | —H. Mueller Mfg. Co. incorporated. |
| 1895 | —First building erected at present Decatur plant location. |
| 1895 | —Hieronymus Mueller wins first American auto race with car imported from Germany and rebuilt. |
| 1900 | —Hieronymus Mueller passes away, March 1. |
| 1902-3 | —Decatur plant enlarged. |
| 1905 | —Eastern Division with offices in New York established. |
| 1907 | —Golden Anniversary Year. "Mueller" trademark registered. |
| 1912 | —Mueller, Limited, organized with plant at Sarnia, Ontario. |
| 1917-18 | —Munitions and other war goods manufactured for allies. |
| 1923 | —Los Angeles branch established. |
| 1924 | —Company name changed to Mueller Co. |
| 1924 | —Copper pipe and fittings added to Mueller line. |
| 1924 | —Plant No. 2 in Decatur added. |
| 1932 | —Mueller's 75th Anniversary year. |
| 1933 | —Chattanooga manufacturing facilities acquired. |
| 1933 | —Steel Tees perfected—providing gas companies with simple, speedy service installations. |
| 1938 | —Line stopper fittings and equipment developed for work on gas or oil lines under pressure. |
| 1941-45 | —Production of war materials claims manufacturing facilities of all plants. |
| 1949 | —Full line of No-Blo® equipment presented to the gas industry. |
| 1950 | —Tamper-proof gas stop introduced. |
| 1957 | —Mueller's 100th year of service to gas and water industries. |



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**A Liquid Medium for the Isolation of Streptococci.** T. G. N. Dresscher. Water (Neth.), **39**:63 ('55). Description is given of method for detn. of faecal streptococci and diplococci in surface water. Liquid medium contg. thallium sulfate is used, in which positive color reaction occurs when streptococci and/or diplococci are present. Method is quick and simple, as microscopic examn. is unnecessary. Details of procedure and of medium are given. Comparison was made between this method and Eijkman test. Results showed greater positive reaction with latter, probably because there are more coliform organisms than streptococci in surface water. This method can, however, be used to supplement Eijkman test, and can be used for purely comparative studies of bact. qual. of water. Method saves materials, as no dilns. higher than 0.01 or 0.001 ml need be used.—*WPA*

**Biology and Metabolism of *Sphaerotilus natans*.** L. Scheuring. Arch. Hydrobiol., 1955, Suppl. XXII, p. 498 ('55). Methods used in quant. detns. of metabolism of *Sphaerotilus natans* included keeping of strains in same nutrient liquid continuously recirculated, in flow-through app. with continuous addn. of new sterile culture liquid, and in usual sterile flasks. Oxygen uptake and respiratory quotient were detd. Strains grew at pH values of 5.8–9 with mass development at pH 6–7. Optimum temps. were between 10° and 15°C. Various waste waters (from cellulose, molasses, etc.) were used. Sugars were decomposed; starch was not utilized. From results approximate calcns. can be made of amt. of fungus developing in streams below cellulose factories. Further expts. helped to det. upper and lower limits of concn. of waste waters permitting growth of *Sphaerotilus*. Finally, constituents of dry matter of *Sphaerotilus* were detd. by paper chromatography.—*WPA*

**Anaerobes in a City Water Supply.** A. T. Willis. J. Appl. Bact., **19**:155 ('56). In paper read at symposium on anaerobes held in London in Jan., 1956, methods used and results obtained in investigation of reliability of sulfite-reduction test for detg. bact. qual. of raw water from city water supply, in comparison with presumptive *coli-aerogenes* test, are described. Standards for classification of water samples according to their *coli-aerogenes* and *Clostridium welchii* contents and percentage confirmation of 1 standard by other are shown in tables and graphs. Results are discussed, and it is concluded that sulfite-reduction test serves little useful purpose either as confirmatory test of presumptive *coli-aerogenes* count, or as supplementary test in assessing bact. purity of water supply.—*WPA*

***Salmonella* and Public Bathing in Open Waters.** F. Steiniger. Arch. Badewesens, **8**:370 ('55). Large number of *Salmonella* required to produce infection is only to be expected when water contains suspended albuminous matter in which *Salmonella* develop strongly. *Salmonella* also develop better in moving than in still water, especially in moving water in which circulation is maintained by tidal movements or variations in level. Conditions in still water appear unfavorable for development owing either to strong growth of bacteria-eating organisms, or to competition of other bacteria, or to presence of antibiotic algae.—*WPA*

**A Radioisotope Technic for the Rapid Detection of Coliform Organisms.** G. V. Levin, V. R. Harrison, W. C. Hess, & H. C. Gurney. Am. J. Public Health, **46**:1405 ('56). Presumptive test for coliform organisms by *Standard Methods* procedure requires 2 or 3 days. Membrane filter test can be made in 20 hr. Radioisotope method attempts to reduce time to 1 hr or less. This is made possible by great sensitivity of instruments to measure small amts. of ionizing radiation and ability of lactose containing carbon 14 to release radioactive carbon dioxide in presence of coliform organisms. In recent method, water to be tested was passed through a membrane filter. Filter was then immersed in tube containing 1-$C^{14}$ lactose obtained from the National Bureau of Standards and incubated at 37°C. Lactose tube was aerated with air from lab. which was metered by controlling bubble rate in tube. In presence of coliform organisms $C^{14}O_2$ ppd. on pad as barium carbonate and air escaped to atm. Exposed pad was dried and radioactivity count made in gas-flow Geiger counter. Presence of coliform organisms was indicated by a count significantly higher than

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normal. However, barium hydroxide pads became radioactive, some radioactive carbon dioxide was held in lactose broth, and 1-$C^{14}$ lactose was expensive. Modification of test procedure reduced lactose broth portions from 5 ml to 0.8 ml, elimd. glass-bead vapor trap as unnecessary, and substituted small cup or plonchet of type used in counting app. for tube. It was found that respiration rates of *E. coli* were longer in exponential growth than they were in log phase. Further refinement was use of Robinson gas-flow counter which, because of its small counting chamber vol., was able to reduce background count from 20–25 cpm to 5–6. It was, therefore, also possible to further reduce 1-$C^{14}$ lactose per test to 0.1 ml, thereby making this method competitive on commercial basis with *Standard Methods* procedure. It was not possible to quantitize test until difference in rates of $CO_2$ production between lag and growth phase organisms is understood. Radioisotope technic was found suitable for qual. presumptive test when gross coliform contamn. was present, which could be detd. within 25 min. In some cases, several hours time was needed. Method is safe and simple; however Robinson gas-flow counter and 1-$C^{14}$ are not yet commercially available. Technique can be adapted for other organisms and for milk and food in addition to water.—*PHEA*

**The Enumeration of *Escherichia coli* I in Sea Water. A Comparison of Counts Determined by the 'Most Probable Number' Method in Liquid Medium with Direct Counts by the Roll-Bottle Method.** P. C. Wood. J. Appl. Bacteriol., **19**:26 ('56). Comparison of 15-tube liquid diln. method for estg. most probable number of *Escherichia coli* I in sea water with direct roll-bottle count at 44° using modified MacConkey's agar revealed no significant differences. Advantages of roll-bottle method include greater accuracy, economy of time and materials, speed with which results are obtained, and greater range of poln. that may be estd. without dilg. sample.—*PHEA*

**Anaerobes as an Index of Faecal Pollution in Water.** A. T. Willis. J. Appl. Bacteriol., **19**:105 ('56). Anaerobes were found to be widely distributed in soil of catchment area of city water supply, and it is suggested that many anaerobes found in water are derived from soil. These organisms do not therefore provide useful index of faecal pollution of water.—*PHEA*

## TASTE & ODOR

**Actinomycetes May Cause Tastes and Odors in Water Supplies.** J. K. Silvey & A. W. Roach. Public Works, **87**:103 ('56). In report of study undertaken during past 7 yrs. at North Texas State College, Denton, on aquatic Actinomycetes and their association with tastes and odors in water supplies, life cycle of these organisms is described, completion of which depends upon favorable supply of nutrients in form of algae, higher plants, and org. matter in shallow areas of streams, lakes and reservoirs. Actinomycete spores persist during unfavorable conditions. By means of special app., described and illustrated in the text, cultures of species of aquatic actinomycetes isolated from various water supplies in USA were reared, factors influencing growth were studied, and volatile compds. responsible for imparting particular tastes and odors to waters during phases of life cycle were adsorbed onto activated carbon for subsequent sepn. and examn.—*WPA*

**Taste and Odor Control at Rock Island, Illinois.** M. A. Miles. Taste Odor Control J., **22**:1 ('56). Description of water treatment plant at Rock Island, Ill., is given. Water is obtained from Mississippi R., and is pumped up 150 ft to treatment plant. Treatment comprises chlorination, addn. of alum and carbon, rapid mixing, addn. of lime, flocculation, sedimentation and filtration. Illustrations and flow diagram of plant are given. Chlorine dosage is controlled so that treated water contains 1 ppm free residual chlorine. This is fairly satisfactory in removing tastes and odors, but for complete removal, active carbon is added, after chlorine contact period of 10–15 min. This removes odors due to nitrogen trichloride formed as result of chlorination. Split treatment has been found to be most satisfactory. —*WPA*

**Influence of Chlorination Practices on Efficiency of Activated Carbon.** A. Y. Hyndshaw. Taste Odor Control J., **22**:1

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('56). Practice of prechlorination of water supplies makes it necessary to give careful consideration to points of application of activated carbon for greatest efficiency. Carbon removes some chlorine from soln. and in turn may lose capac. by becoming coated with chlorine. In addn. reaction products of chlorine and organics may be more difficult to absorb onto carbon than unreacted materials. Adding carbon ahead of chlorine overcomes these difficulties. This practice will also remove 25%–60% of chlorine-demanding materials which will help offset cost of carbon. In new plants it is suggested that predetention basin permitting 15 min contact of water with carbon after thorough mixing be incorporated into constr. In existing plants other means may provide separate treatment such as application of carbon in mixing basin and chlorine toward end of basin.—*PHEA*

**Crusading Black Knights in Parts Per Million.** R. D. Shellenberger. Taste Odor Control J., **22**:1 ('56). Activated carbon is used to eliminate musty odor in raw water supply for Homer City, Pa. Lab. and plant-scale tests showed that addn. of 10 ppm carbon would produce palatable water. Water is pumped from Yellow Creek to mixing basin where lime and carbon are added by separate dry feeders to influent. Experience shows that it is more difficult to remove taste- and odor-producing substances after chlorination, therefore chlorine is added at end of mixing chamber, allowing 10–15 min contact with carbon before chlorination. Also, this method requires less chlorine. Since Yellow Creek water has high iron content, it is necessary only to adjust pH value with lime to produce good flocculation. Water is held in sedimentation tanks for about 6 hr, then filtered through rapid sand filters. Results of tests are tabulated.—*WPA*

**Water Treatment Plant Design for Taste and Odor Control.** K. Klaffke. Taste Odor Control J., **22**:6 ('56). At Hefner water treatment plant at Oklahoma City, Okla., it was found that variations in taste and odor called for flexibility in design of treatment plant, incorporating plenty of contact time, and allowing for changes in method and sequence of treatment. Tests showed that activated carbon was most successful agent. To avoid problems of dust control carbon is stored and fed in form of slurry of 1 lb carbon to 1 gal of water which is pumped from underground storage tanks to precision feeders and feeder tanks, and distributed through stainless-steel splitter box consisting of 6 V-notch weirs. Plant surfaces in contact with slurry are rubber lined to avoid corrosion.—*WPA*

**Taste and Odor Problems at Valparaiso, Indiana.** R. Coate. Taste Odor Control J. (Feb. '57). Lake turnover and algae have caused severe taste and odor problems at times in Valparaiso supply. These tastes and odors were controlled best when activated carbon was added to raw water and a 4-hr contact time was permitted before chlorine was added.—*PHEA*

## AQUATIC ORGANISMS

**Population Density of the Limnetic Cladocera of Pymatuning Reservoir.** G. W. Borecky. Ecology, **37**:719 ('56). Samples taken during the period Jun. 1952–Sep. 1953 from lakes that constitute Pymatuning reservoir were analyzed for numbers of Cladocera per liter, pH, and ppm of dissolved oxygen, free carbon dioxide, bicarbonate and carbonate ion. In numbers of Cladocera, particulate org. matter, and percentage of org. matter in bottom soils, the 3 lakes—Sanctuary, Middle, and Lower—rate highest, intermediate, and lowest respectively. Densities of Cladocera are correlated with concns. of oxygen, bicarbonate, and carbonate ions. Anal. of variance revealed significant differences between lakes in densities of Cladocera, amounts of bicarbonate and carbonate ions. Sums of squares and products associated with lakes for densities of Cladocera, carbonates, and bicarbonates, having been freed of effects of variability between years and between levels of hydrogen-ion concn., were used in multiple regression and covariance anal. As result of this anal. between-lakes errors of est. were no longer significantly different from errors of est. for exptl. error; lakes were statistically reduced to common level for concns. of hydrogen ion, bicarbonate ion, and carbonate ion. These 3 chem. factors are regarded as indexes of photosynthetic activity which is, in turn, considered to be a measure of amt.

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## HOW TO SELECT
## WATER-CONDITIONING EQUIPMENT
(NO. 5 OF A SERIES)

# Ion Exchange Equipment

**Ion exchangers** are solids which can take a "charge" of cations or anions from one liquid and exchange them for different ions of the same polarity in another liquid. Example: "Permutit Q" Cation Exchanger, a sulfonated polystyrene resin. When operated on the "sodium cycle," this resin picks up calcium, magnesium, iron, manganese or aluminum cations from water containing these materials and gives off sodium cations in exchange. When exhausted, the resin is regenerated with a brine (sodium chloride) solution that supplies new sodium cations.

The Table below lists ions commonly found in water and the ion-exchange systems by which they can be removed.

**Softening**: Removing calcium and magnesium ions that cause boiler scale, soap curd, etc. Done with a cation exchanger, sodium cycle, which also removes iron, manganese and aluminum ions.

**Dealkalizing**: Removing bicarbonates and carbonates, generally from boiler feedwater, to reduce corrosion due to $CO_2$ in condensate returns. Done in 2 steps: cation exchanger, sodium cycle, then strongly basic anion exchanger, chloride cycle.

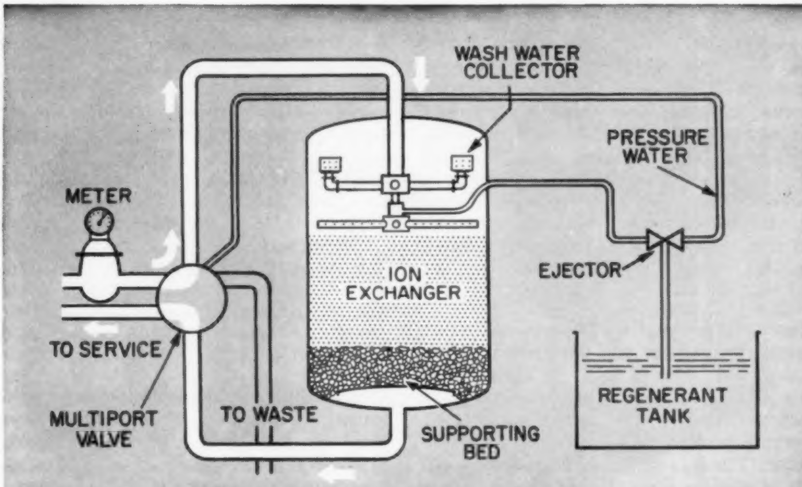
**Demineralizing**: Removing cations and anions. Up to nine or ten combinations of exchangers with one to four steps are used depending on the raw water and the degree of purity required for a specific use.

### Functions of equipment

Ion exchange equipment is designed to accomplish these basic cycles: The *service run* during which the water flows through the bed of ion exchanger (usually downflow); *backwashing* (upflow) for removing suspended solids filtered out by the ion exchanger; *regenerant introduction* (either upflow or downflow) which restores the capacity of the ion exchanger and *rinsing* which removes the excess regenerant from the bed.

A manual or automatic motor-driven multiport valve replaces a number of individual valves and greatly simplifies regeneration. Rubber-lined multiport valves are used under corrosive conditions.

| | | | | | |
|---|---|---|---|---|---|
| CATIONS | Calcium | $Ca^{++}$ | Exchanged for sodium ions by CATION EXCHANGER regen. with sodium chloride. | Exchanged for hydrogen ions by CATION EXCHANGER regen. with acid. | |
| | Magnesium | $Mg^{++}$ | | | |
| | Iron | $Fe^{++}$ | | | |
| | Manganese | $Mn^{++}$ | | | |
| | Aluminum | $Al^{+++}$ | | | |
| | Sodium | $Na^{+}$ | | | |
| | Potassium | $K^{+}$ | | | |
| ANIONS | Chloride | $Cl^{-}$ | Taken up as complete acid molecule by WEAKLY BASIC ANION EXCHANGER regen. with soda ash or caustic. | | Exchanged for hydroxyl ions by STRONGLY BASIC ANION EXCHANGER regen. with caustic. |
| | Sulfate | $SO_4^{=}$ | | Exchanged for chloride ions by STRONGLY BASIC ANION EXCHANGER regen. with sodium chloride. | |
| | Nitrate | $NO_3^{-}$ | | | |
| | Bicarbonate | $HCO_3^{-}$ | | | |
| | Carbonate | $CO_3^{=}$ | | | |
| | Silicate | $HSiO_3^{-}$ | | | |




SINGLE-BED ION EXCHANGE UNIT

Length of service run is usually controlled by the volume of water through an electric-contact water meter or by automatic water-quality testing instruments such as a conductivity meter.

## SINGLE-BED UNITS for softening, dealkalizing, demineralizing

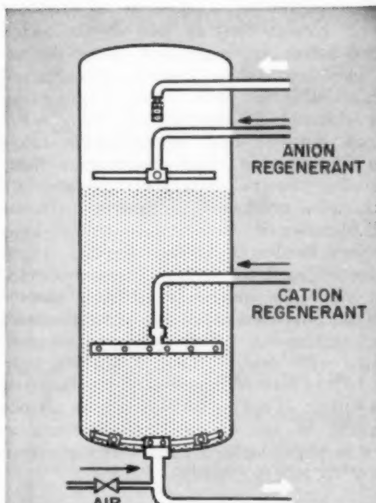
These units contain one type of ion exchanger (cation or weakly basic anion or strongly basic anion). They are similar to pressure filters with ion exchanger in place of the sand and a more efficient distribution and collection system for more uniform flow through the bed.

Two or more single-bed units are required for demineralizing . . . one or more for a cation exchanger and one or more for each type of anion exchanger used.

## MIXED-BED UNITS for demineralizing

Mixed-bed units contain both cation and anion exchangers. These are thoroughly mixed prior to the run and provide a multiple-step demineralization.

Backwash rate is closely controlled so that it separates the ion exchanger resins by lifting the lighter anion resin beds over the heavier cation resin. The beds are then regenerated and rinsed while separated, then mixed by air jets from the bottom of the tank and given a final downward rinse before the service run.




MIXED-BED ION EXCHANGE UNIT

For information on ion exchange resins and equipment, as well as other water-conditioning equipment, please write:
**THE PERMUTIT® COMPANY,** Dept. JA-9, 330 West 42nd Street, New York 36, N.Y., or Permutit Company of Canada, Ltd., Toronto 1, Ontario.

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of food available for Cladocera. The 3 lakes were, therefore, statistically reduced to a common level of photosynthetic activity or equal amts. of food; under these conditions numbers of Cladocera did not differ significantly between lakes. On basis of these findings it was concluded that, in environment provided by Pymatuning, densities of Cladocera are primarily detd. by food supply and show significant correlation with chem. and phys. factors that are related to food supply.—*PHEA*

**Chlorophyll $a$ in the Phytoplankton in Coastal Waters of the Eastern Gulf of Mexico.** N. MARSHALL. J. Marine Research, **15**:14 ('56). Chlorophyll $a$ was measured about twice a month for 1 yr at 3 surface stations along axis of Alligator Harbor, Florida; addnl. observations were made at stations along Tampa Bay and elsewhere in coastal waters of eastern Gulf of Mexico. Greatest concns. toward head of estuaries studied were probably associated with low dispersal rates and with mixing of benthic forms into plankton of shallow water. Except for red tide waters which yielded values approximating spring flowering in Long Island Sound, cholorophyll concns. offshore were low. Comparison with chlorophyll observations from other regions suggests that phytoplankton crops from Florida west coast approximate those of similar waters elsewhere. In addition, expts. were conducted to ascertain chlorophyll histories of water samples held in light and dark bottles at different depths. Light bottles exposed to surface or near-surface light intensities commonly exhibited chlorophyll decline even when the phytoplankters were multiplying. This decline diminished rapidly with depth. Though surface light may be too intense for some phytoplankters, such fading is not to be regarded as serious deterrent to use of chlorophyll values as index to phytoplankton mass where plankton is free to mix vertically.—*PHEA*

**Electrokinetic Phenomena of Planktonic Algae.** K. J. IVES. Proc. Soc. Wtr. Treatment Exam., **5**:41 ('56). Possibility of an electric charge residing on fresh-water planktonic algae is first mooted, and description of exptl. method, with some of theory involved, is described to detect and measure this charge. Results are given for zeta potential and charge density for varying genera of naturally-occurring and cultured algae, and effects of ionized salts, pH variation, and algicides are assessed and discussed. All algae investigated were electronegative at all pH values, although minimal values of zeta potential and charge density were found near neutral pH for algae in ion-free water. Algicides vary charge, one decreasing it, others increasing it. Results are discussed and some criticisms of exptl. method are met. Application of information derived from study of algal flocculation with chem. coagulants, and electrophoretic sepn. of algal species is described.—*PHEA*

**Annual Cycle of Net Plankton in Fluctuating North-Central Colorado Reservoir.** E. B. REED & J. R. OLIVE. Ecology, **37**:713 ('56). Limnological investigation of annual standing crop of net plankton in fluctuating reservoir was conducted from Oct. 1953 to Sep. 1954 on Horsetooth Reservoir in north-central Colorado. Chem., phys., and biol. samples were taken at 2-wk intervals. Plankton was obtained by means of 10-l Juday trap. Water level fluctuated markedly from max. depth of 150 ft (46 m) in April to min. depth of 45 ft (14 m). Horsetooth Reservoir produced avg. dry weight of plankton of 32.2 lb per acre and may be considered mestotrophic in nature. Total net plankton production for year was estd. to be of order of 6,000 tons. —*PHEA*

**Photosynthesis and Respiration of the Phytoplankton in Sandusky Bay.** A. G. MCQUATE. Ecology, **37**:834 ('56). Study of photosynthesis and respiration of natural communities in Sandusky Bay, on the southwest shore of Lake Erie, was made from Feb. 2 to Jun. 18, 1954. Average photosynthetic rates, when phytoplankton counts were high, amounted to 8 $\mu$moles $CO_2$ removed/hr/$10^{10}\mu^3$ and 2.4 $\mu$moles/hr/mg ash-free dry weight of suspensoids. Photosynthetic quotient ($CO_2/O_2$) observed had value of 0.87. Apparent photosynthesis under completely natural conditions amounted to about 75% of total photosynthesis as measured in clear and blackened bottles. Relatively high photosynthetic rates at low levels of phytoplankton pops. indicate presence of important quans. of organisms not detected by observation under 100× magnification. Respiratory quotient ($CO_2/O_2$) of 3.3 was ob-

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served, suggesting $CO_2$ evolution considerably in excess of $O_2$ consumption. It is suggested that microbial components may be responsible for the high photosynthesis associated with low phytoplankton vols. and for high value of respiratory quotient.—*PHEA*

**Photosynthesis in the Algae.** R. W. Krauss. Ind. Eng. Chem., **48**:1449 ('56). Purpose of this paper is to review briefly photosynthetic characteristics of algae within broader framework of their requirements for growth and reproduction. Energy relationship in photosynthesis is covered in considerable detail as well as biochem. reaction which releases oxygen. Effects of intermittent illumination, carbon dioxide supply, temp., nutrition, and resulting org. products are discussed.—*PHEA*

**The Comparative Physiology and Biochemistry of the Blue-Green Algae.** G. E. Fogg. Bacteriol. Rev., **20**:148 ('56). Some of physiological and biochem. features of blue-green algae, including cell physiology, nutrition, and chem. compn., are discussed. Particular emphasis is placed on similarities and differences exhibited by this group as compared to other organisms.—*PHEA*

## POLLUTION CONTROL

**The Proposed General Law for the Control of Water Resources and Its Importance for Water Supply.** O. Kohl. Gas- u. Wasserfach (Ger.), **97**:317 ('56). Author surveys efforts made to unify German water laws and discusses provisions of proposed general water law, of which text is given. Provisions of various sections of the law are discussed and author then deals with its importance for public water supply and with further legal enactments required for provision and maintenance of satisfactory conditions of supply.—*WPA*

**Federal Water Pollution Control Legislation.** M. D. Hollis & G. E. McCallum. Sewage & Ind. Wastes, **28**:306 ('56). Authors review policy of USPHS with regard to control of water poln., and indicate legislation now under consideration to extend and improve present Water Pollution Control Act.—*WPA*

**Water Pollution Control—Stream Standards v. Effluent Standards.** W. B. Hart. Ind. Eng. Chem., **48**:65A ('56). Author discusses legal and technological reasons for adopting stream standards in connection with prevention and abatement of river poln. by industrial waste discharges. Effluent standards, it is suggested, should be considered when it is desirable to trace pollutant to its source and to eliminate cause of poln., particularly where industry is dense and waste discharges numerous.—*WPA*

**Cleaner Rivers.** M. Lovett. Contract. Record, **68**:19 ('57). In paper presented to Institution of Civil Engineers, author outlined principal provisions of Rivers (Prevention of Pollution) Act, 1951, and discussed impounding of river headwaters for release when water is scarce, need for sewage-works effluents to comply with Royal Commission standards, importance of improving design of new sewage works, and importance of adequate treatment of trade waste waters. —*WPA*

**Solving Pollution Problems Through Cooperation.** J. M. Jarrett. Proc. Am. Soc. Civil Engrs., No. 642 ('55). It is pointed out that in dealing with problems of stream poln. an understanding of political and social sciences as well as technical knowledge is necessary, and that cooperation between state, research bodies, municipal authorities and industrial parties is most important. Policy of cooperation adopted in N.C. and legislation introduced by state in connection with abatement of stream poln. are outlined, and examples are cited of programs carried out in several municipalities in N.C. for treatment of industrial waste waters with sanitary sewage.—*WPA*

**Treatment of Polluted Waters by Flocculation.** H. Koeck. Ann. Mines Belg., Spec. No., 114–21 ('56). Theory of flocculation is discussed. Comparative flocculating power of different inorg. electrolytes is listed in table: sulfates, chlorides, and nitrates of Ca, Ba, K, Na, Li, and $NH_4$ decant much slower than hydroxides of these cations which shows that OH ion favors flocculation. Among org. colloidal flocculants potato starch is most reactive one; in general, colloidal vegetable flocculants are more reactive than animal flocculants. Dose of flocculant needed depends upon concn. of suspended solid material and proportion of impalpable material in water.—*CA*

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**Harry F. Bower** has been named sales manager of the Cast Iron Pipe & Foundry Dept., James B. Clow & Sons, Chicago. Mr. Bower, who succeeds the retiring V. M. Wall, was formerly assistant manager and has also acted as director of sales for the Iowa Valve and Eddy Valve subsidiaries of Clow.

**A president's pants** have been the subject of great mystery ever since the conclusion of the Canadian Section meeting in Winnipeg last June. And as the president is AWWA's own, we feel we can no longer ignore the smoke of innuendo and insinuation that has been hanging over the headquarters office for more than a month now. As a matter of fact, as all evidence seems to point to the fact that the president *was* caught with his pants down and as no amount of respectful silence is likely to eradicate that from the memories of those present, we feel that a disclosure of the information received to date can only be helpful in preventing exaggeration of the breaches of presidential protocol thereby involved:

ITEM: On Jun. 28, from an allegedly "disinterested" observer, we received a communication which concluded with this statement:

> After carefully sifting the evidence—verbal, written, photographic, and heavily biased, I should like to affirm categorically that, when leaving a large Winnipeg hotel at 7:40 AM on Thursday the 24th of June, our highly respected and distinguished-looking president was not—repeat, NOT—without his trousers; he was carrying them over his arm.

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and carried a postscript citation to II Kings, Chapter 14, Verse 3: "The Lord taketh delight in no man's legs."

ITEM: On Jul. 2, from AWWA past-president Louis R. Howson, an eyewitness, we received a communication which contained this allusion:

As three of us were leaving the Royal Alexandra Hotel in Winnipeg, our Honorable President had an experience which would make interesting reading to many AWWA members.

ITEM: On Jul. 8, from immediate AWWA past-president Paul Weir, another eyewitness, we received a communication which contained the following references to a "breathless incident":

It is reliably reported that our president's breath came in short pants until a rescue was effected by a bellboy bearing a garment that is usually used to cover the lower portion of the male's anatomy. . . . All present on this inauspicious occasion solemnly agreed to give our president a reasonable length of time to explain how he almost lost his dignity.

ITEM: On Jul. 25, from present president Fred Merryfield, the party presumably parted from his pants, we received an extraordinary communication packed with quotations from literary greats from Thucydides to Maugham and referring to the "highly imaginative story" concocted by the "letter writers" as a fisherman's if not a fish wife's tale, of the type "resorted to to detract from their friends' prowess." Space does not permit a full quotation of the presidential "defense," nor our understanding an intelligent selection of the significant, but one quotation which must be to the point is:

And this brings us to the "Sixth Age Shift" of Shaftesbury. "Into the lean and slippered pantaloon with spectacles on nose and pouch on side. His youthful hose well saved a world too wide. His shrunk shank; and his big, manly voice. Turning again towards childish treble, pipe, and whistles in his sound. Last scene of all, that ends this strange eventful history, is second childishness, and mere oblivion, sans teeth, sans eyes, sans pants, sans everything."

and a postscript citing Ibsen's advice: "You should never wear your best trousers when you go out to fight for freedom or truth."

Actually, of course, we know there is no truth to the insinuations at all. We know Fred personally, we've seen him innumerable times, and we can attest to the fact that he always has his pants on.

**US Pipe & Foundry Co.,** Birmingham, Ala., announces a number of Sales Dept. personnel changes: George J. Bogs is the new assistant Pacific Coast sales manager, with headquarters at Los Angeles; Bartlett G. Bretz has been promoted to assistant western sales manager, working out of Chicago; and Buddy P. Amis and Hoyt N. Burns have been named sales agents for Kansas City and Houston, respectively.

**Sensorship** of your lawn does involve cutting it, but only indirectly, for the sensor is merely the underground agent of a new device that measures soil moisture as a basis for proper lawn sprinkling. Now being ground tested by the Long Island Water Corp., the "Moisture Meter," a product of K Industries, Hicksville, N.Y., includes a resistivity meter that operates on house current and one or more sensors, installed at grass-root level and con-

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nected to the meter by wire. The MM is by no means the first device of its kind, but it does seem to offer possibilities for a lot more elaborate system than did the earlier wettesters.

In providing a multiple-zone meter, for instance, the MM makes possible the measurement of moisture content in as many as four different zones of a yard merely by switching a multiple pole switch from one zone to another. What is still more exciting, however, is the possibility of connecting the meter to electrically operated valves, bringing automation into the backyard. Not only can the grass roots thus be permitted to turn on the water when they need it, but, by the introduction of a time clock, they can be made to wait for legal sprinkling hours where restrictions have been imposed or, by an interlock system, to wait their turn when other areas are using the sprinkling facilities.

All this, of course, merely whets our appetite. It is the Compleat Lawnometer that we are waiting for—one that measures not only moisture, but grass height, feed need, weed infestation, and grub content and then activates the remote-control mower, spreader, roller, aerator, and the endless list of other equipment now required to maintain a lawn. On the other hand, when we add to the $59.50 cost of a four-zone MM, the cost of electrically operated valves and the plumbers to install them, the cost of time clocks and interlocks, not to mention their maintenance, we begin to realize that the very best way in which we can cooperate with the inventor of the MM in his very laudable purpose of conserving water is to turn to sense instead of sensors and stick with our own invention—the green concrete lawn.

**The National Safety Congress,** to be held in Chicago Oct. 21–25, under the sponsorship of the National Safety Council, will include a Water Utilities Session on Thursday afternoon, Oct. 24, at the Conrad Hilton Hotel. The scheduled speakers are: James E. Hickman, Los Angeles; Raymond J. Faust, New York; V. A. Appleyard, Philadelphia; A. C. Rener, Los Angeles; and Arthur J. Webb, East Bay Municipal Utility Dist., Oakland, Calif.

**H. B. Horton,** chairman of the board, Chicago Bridge & Iron Co., was honored at a reception last month on the occasion of his 50th anniversary with the company. Mr. Horton has been a director of the firm since 1913.

**S. E. Allen** has been appointed vice-president and general manager of all operations of Graver Tank & Mfg. Co., East Chicago, Ind. W. M. Broxham is the new vice-president and general manager of the company's plate and alloy products division. Mr. Allen was formerly general manager of plate products.

**J. Calvin Affleck** has been appointed advertising manager of Keasbey & Mattison Co. Formerly advertising and sales promotion manager of DuMont's Television Receiver Div., Mr. Affleck succeeds Walter C. Dodge, who is retiring after nearly 50 years with Keasbey & Mattison.

**Anthony Anable** has rejoined the staff of Dorr-Oliver Inc., Stamford, Conn., as manager of the firm's Technical Data Div. In recent months, prior to his return to the staff, he had been acting as a consultant to the company in connection with its technical training program.

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**'Government in emergency'** is the theme of this year's Civil Defense Week (Sep. 15–21). In support of this theme, the Federal Civil Defense Administration has issued the following statement:

The state of weapons development that exists today and the fantastic breakthroughs that are announced with grim regularity force upon all of us two conclusions: An allout attack upon the United States might [1] completely destroy a great number of cities as well as targets located in rural areas, and [2] contaminate many areas, both urban and rural, with radioactive fallout sufficient to make them uninhabitable for periods of days to years. In addition to this threat, every year some 400 natural disasters take their toll in lives and property in the United States.

What can we do to cope with a threat of the magnitude of thermonuclear warfare, or with the increasing devastation of natural disasters? The most sensible thing we can do is to build civil defense readiness into normal government at all levels—federal, state, and local—for within government at all echelons there is a capacity for leadership in time of crisis, a leadership that will provide swift action in an emergency.

Governments in their day-to-day functions have always been engaged in certain civil defense activities without calling them that. In time of natural disasters these services already in existence, such as fire, health, and police, are intensified. However, to meet the magnitude of a thermonuclear attack, these services will have to be supplemented by functions peculiar to this kind of emergency. For example, there is a need to prepare for radiological monitoring—an operation that does not exist as a part of any normal government service.

This dynamic capability of government to act promptly and effectively in an emergency, whether it be a tornado, flood, or enemy attack; this civil defense readiness built into government enabling it to spring into action quickly to cope with disaster of any kind is the most sensible solution to the problem of survival in this age of peril.

**Charles S. Howard** has retired as staff research chemist with the Water Quality Branch, Water Resources Div., USGS, after 37 years. A pioneer in United States water quality investigation, he has written many papers on the chemical quality of water and is particularly well known for his contribution to the knowledge of the sediment and chemical characteristics of the Colorado River. Mr. Howard has been an AWWA member since 1943.

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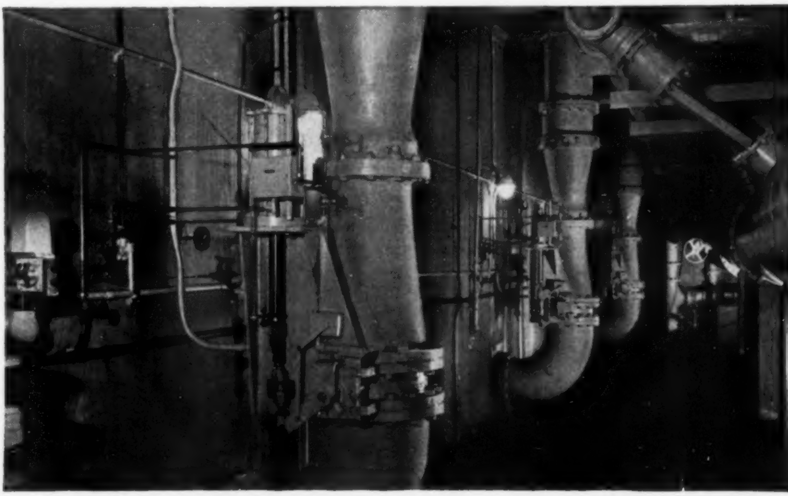

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**Ralph S. Estus** is the new sales manager for Hersey Mfg. Co., Dedham, Mass. He joined the firm in 1955, after being associated with Fuller Brush Co.

**'Which suit has the bid?'** is Richmondese, these days, for "which official of the Richmond, Va., purchasing department is handling the order?" The story behind the bridgework is the decision by the department to substitute a coded punch for a rubber stamp in designating on duplicate purchase orders which official signed the original. The code chosen was the four suits of a deck of playing cards. "The new method," Hearts—that is, Director J. W. Huffman—reports, "will save time processing orders and will help us in expediting service." What disturbs us, though, is the basis of suit assignments: hearts to the director; clubs to the assistant director; diamonds to the contracting officer; and spades to the purchasing officer. Culbertson would turn over in his grave if he knew. Our best guess, not knowing the individuals involved, is that a handsome director and his strict assistant work with a fiancéeful contracting officer and a hardworking purchasing officer. We'd have stuck to bridge protocol as protection against an unsuitable replacement.

**James W. Dashner,** formerly with General Electric Co., has been appointed chief engineer of Kennedy Valve Mfg. Co., Elmira, N.Y.

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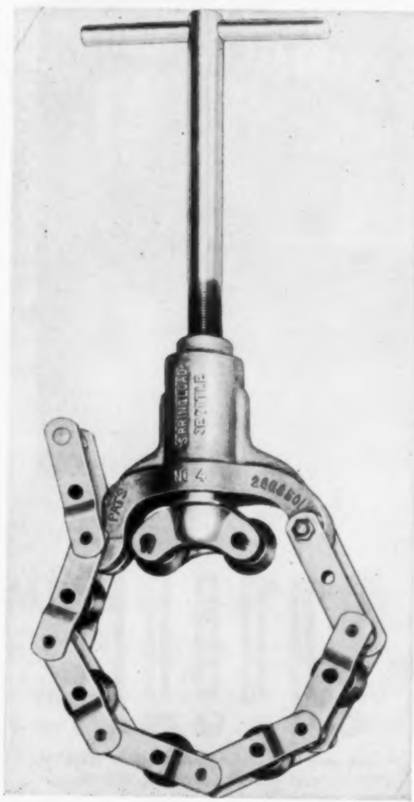
**A pipe cutter** designed for 1½–4-in. iron or concrete pipe and weighing only 4½ lb is being marketed by Spring Load Mfg. Corp., Seattle, Wash. The "No. 4" cutter, intended primarily for residential or light commercial jobs, lists at $29.95.



**Hydraulic Development Corp.** has announced that its European subsidiary, Hydrotite, S.A., Madrid, is now manufacturing and distributing Hydro-Tite jointing material throughout the Continent.

**Barrett Div.**, Allied Chemical & Dye Corp., has formed an Industrial Tar Products Sales Dept., consolidating two formerly separate sales organizations. Manager of the new department, located in New York City, is V. C. Otley.

**Charles N. Perry** has been appointed factory manager of the Rockwell Mfg. Co. plant at Porterville, Calif. He was formerly purchasing agent for the company's Oakland, Calif., plant.

**The self-priming jet pump** illustrated below is said to be able to produce more than 450 gph. Appropriately named "Mijet," it is intended for household use and is designed to sell for less than $30. The manufacturer is Jacuzzi Bros., Inc., Richmond, Calif.

**Edwin C. Goehring**, general manager of the Beaver Falls (Pa.) Municipal Authority, died Jul. 14, 1957, after an extended illness. He was graduated from Rensselaer Polytechnic Institute in 1923 with a degree in chemical engineering and began his career as a chemist for the Roanoke (Va.) Water Works Co. In 1925 he became chief chemist for the Beaver

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Valley Water Co. After it was purchased by Consumers Water Co. in 1926, he acted as chemical adviser to the numerous subsidiaries of that organization. In 1940 the Beaver Valley Water Co. was purchased by the Beaver Falls Municipal Authority, and Mr. Goehring was appointed assistant manager of the authority, a position he held until December 1956, when he was named general manager.

An AWWA member since 1939 and a past-chairman of its Pennsylvania Section, Mr. Goehring also belonged to NEWWA and the Pennsylvania Water Works Operators Assn.

**Daniel C. Nolan Jr.**, retired town engineer and commissioner of public works of Greenburgh, N.Y., and president of Wulff Engineering Co., Tarrytown, N.Y., died Jul. 28, 1957, at the age of 68. He represented the Greenburgh Water Dept. in AWWA and was a member of the Westchester County Water Works Assn.

**John F. Stehling**, superintendent, Locust Valley (N.Y.) Water Dist., died Jul. 8, 1957. In 1924, after service with the Hicksville and Glen Cove, N.Y., water utilities, he took over the direction of Locust Valley's 2-year-old water district, a position he retained until his death. His efficient management is attested to by the fact that the district is now debt free.

An AWWA member since 1935, Mr. Stehling also belonged to the Long Island Water Conference.

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**The Tennessee legislature's** recent passage of a bill providing for reimbursement of utilities' costs due to relocation in federally aided highway projects can largely be credited to the work of a committee headed by Charles H. Bagwell, water department business manager at Knoxville. In pushing the bill through the legislature, Bagwell and his committee had to overcome the opposition of the state highway commissioner, the Tennessee Muncipal League, and the County Judges Assn.

**Frank L. Mascitti** has been named industry sales manager, water and wastes treatment, for the Industrial Div. of Minneapolis-Honeywell Regulator Co. Mr. Mascitti, who has been with the firm for 7 years, will make his headquarters at the division's main plant in Philadelphia.

# Employment Information

Classified ads will be accepted only for "Positions Available" or "Positions Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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**Twenty years in Water Works Field. Opera**tion Executive, Public Relations. Completing 3 years as Executive Overseas Water and Sewage Operations. Resume will be furnished. Box 91, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

# Service Lines

**Draftsmen and engineers** will find 59 useful "Time-saving Tips" in a 40-page illustrated booklet available from Reader Service Div., Frederick Post Co., 3650 N. Avondale Ave., Chicago 18, Ill.

**Float valves** for water level control in tanks, reservoirs, mixing basins, and other applications are described in a 16-page bulletin, No. W-5, which can be obtained from Golden-Anderson Valve Specialty Co., 1221 Ridge Ave., Pittsburgh 33, Pa.

**Vertical turbine pump** design and selection data and methods are covered in a 72-page spiral-bound book, with tables, photographs, and drawings, entitled "The Answers to Your Questions About Layne Vertical Turbine Pumps." Requests for copies should be sent, on letterhead stationery, to Layne & Bowler, Inc., Memphis 8, Tenn.

**Corrosion inhibitor** *"CS,"* for closed circulating water systems, is described in a 6-page folder offered by Hagan Chemicals & Controls, Inc., Hagan Bldg., Pittsburgh 30, Pa.

**Service fittings,** corporation and curb stops, rough plumbing, and tapping machines are among the items described and illustrated in a tab-indexed, spiral-bound, 125-page catalog of water service products issued by Kitson Valve Div., Welsbach Corp., Philadelphia 29, Pa.

**A volumetric feeder** designed to feed dry material whether light or heavy, as lumps or as powder, is described in an 8-page bulletin, No. 20-P2, available from Omega Machine Co., Div. of B-I-F Industries, 345 Harris Ave., Providence 1, R.I.

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## *Service Lines*

(*Continued from page 104 P&R*)

**Controlled-volume pumps** for metered pumping of noncorrosive liquids at normal temperatures, as in boiler feed or cooling-water treatment, are the subject of Bul. 557, issued by Milton Roy Co. Copies of this 4-page brochure on "H20" pumps can be obtained from the company at 1300 E. Mermaid Lane, Philadelphia 18, Pa.

**'Laminair,'** a form of pneumatic transmission which operates by producing an output air pressure varying directly with flow through a venturi tube, nozzle, or orifice plate and transferable to a distant receiving instrument, is covered in Bul. 750 (8 pages), issued by Simplex Valve & Meter Co., 7 E. Orange St., Lancaster, Pa.

**Protection of underground pipe** from corrosion with "Scotchrap" insulation tape is the subject of a 24-page booklet containing step-by-step photos and instructions for wrapping bends, straight sections, joints, and fittings. Copies may be obtained from Dept. D6-262, Minnesota Mining & Mfg. Co., 900 Fauquier St., St. Paul, Minn.

**Solenoid valves** manufactured by Automatic Switch Co. are described, with selection data, prices, and illustrations, in a 32-page condensed catalog, ASCO No. 201, available from the company at 391 Lakeside Ave., Orange, N.J.

**Cathodic protection** with Duriron and Durichlor anodes is the subject of an 8-page bulletin, No. DA/1b, issued by Duriron Co., Inc., Dayton 1, Ohio.

**Air valves** for various applications are described, with specifications and operating data, in a 28-page illustrated catalog issued by Multiplex Mfg. Co., Dept. O, Berwick, Pa.

**Emergency lighting equipment** of several types is described in a 4-page brochure, "Light Warden" Catalog 11-1957, obtainable from Electric Cord Co., 195 William St., New York 38, N.Y.

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We are paying billions for land conservation and reclamation because our very life depends upon it. And we are lucky — there's land to reclaim. But what about our diminishing water supply? When that's gone

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are lucky — there's land to reclaim. But what about
now—with Badger Meters. They're the best investment you can make for your community's future. Badger Meters replace impractical and unjust flat rates with a fair-share, fair-pay program for everybody. Accurate metering proves to consumers that the best things in life are far from free. That's when water waste stops — conservation begins. What's more, Badger Meters put your water system on a profitable, business basis.
Choose the specific meters you need from the complete Badger Meter line of outstanding disc, turbine and compound meters — 5/8-inch through 12-inch sizes. They're precision-engineered, using the finest alloys for lasting, accurate service. Call a Badger Meter representative for facts — or write for literature today.
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AMERICAN WATER WORKS ASSOCIATION

**NEW MEMBERS**

*Applications received Jul. 1–31, 1957*

**Anderson, Russell S.,** Asst. Chief Water Plant Operator, Filtration Plant, Box 528, Trenton, N.J. (Jul. '57) *P*

**Angel, Tom,** Mgr., N. Johnson City Utility Dist., 306 W. Main, Johnson City, Tenn. (Jul. '57) *M*

**Ashabraner, Paul,** Salesman, Warren Chem. Co., Inc., Chicago Heights 3, Ill. (Jul. '57) *P*

**Austin, Donald Stafford,** Vice-Pres., H. A. R. Austin & Assoc., Ltd., 850 Richards St., Honolulu 13, Hawaii (Jul. '57) *R*

**Bailey, G. W.,** Supt., Water & Sewer Dept., Corning, Ark. (Jul. '57) *P*

**Baker, Gordon H.,** Industrial Comr., North York Township, Munic. Offices, Willowdale, Ont. (Jul. '57)

**Bishop, Floyd A.,** Partner, Bishop & Spurlock, Box 598, Lander, Wyo. (Jul. '57) *MRPD*

**Blair, Robert,** Pumping Plant Engr., Dept. of Water Supply, 11000 E. Eight Mile Rd., Detroit 5, Mich. (Jul. '57) *M*

**Brookbank, R. E.,** Supt., Water Dept., Pendleton, Ind. (Jul. '57)

**Brooks, Paul,** Asst. Supt. of Stores, Dept. of Water & Power, 410 Ducommun St., Los Angeles 12, Calif. (Jul. '57) *MD*

**Burke, John Thomas, Jr.,** Area Mgr., National Aluminate Corp., 708 Gypsy Lane, Pittsburgh 34, Pa. (Jul. '57) *P*

**Carey, Richard B.,** Chem. Sales & Service Engr., Hagan Chemicals & Controls Co., 1485 Bayshore Blvd., San Francisco 14, Calif. (Jul. '57) *RPD*

**Carr, Alfred Lewin,** Asst. Area Engr., Corps of Engrs., US Army Area 2, 112 Montgomery, Syracuse, N.Y. (Jul. '57) *PD*

**Christensen, George C., Jr.,** Chemist, Norristown Water Co., Norristown, Pa. (Jul. '57) *MRPD*

**Cook, Grover William,** Aquatic Biologist, State Bd. of Health, 1330 W. Michigan St., Indianapolis, Ind. (Jul. '57) *RP*

**Cook, James B., Jr.,** Sales Mgr., Gen. Products Div., Hays Mfg. Co., 12th & Liberty Sts., Erie, Pa. (Jul. '57) *D*

**Corlew, Van,** Supt., Water Dept., Dickson, Tenn. (Jul. '57) *MRPD*

**Coulter, Joe A.,** Sales Engr., Rockwell Mfg. Co., Box 2126, Houston 1, Tex. (Jul. '57)

**Crowley, Edwin L.,** Field Engr., Infilco, Inc., Box 5033, Tucson, Ariz. (Jul. '57) *P*

**Dameron, Zack,** Supt., Water & Sewer Dept., Truman, Ark. (Jul. '57) *M*

**Davitt, Michael J.,** Gen. Sanitarian, Southwest Branch Office, State Bd. of Health, 307 Harned Ave., Harned, Ind. (Jul. '57) *M*

**Dinauer, Charles R.,** City Engr., 2005—10th Ave., South Milwaukee, Wis. (Jul. '57)

**Eckenrode, Clement W.,** Sales Engr., Rockwell Mfg. Co., Box 2126, Houston 1, Tex. (Jul. '57) *D*

**Erie Mining Co.,** R. L. Hein, Mech. Engr., Hoyt Lakes, Minn. (Corp. M. Jul. '57) *MRPD*

**Ferguson, O. D.,** Supt., Water Dept., Woodstown, N.J. (Jul. '57) *MD*

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**Ford, M. E., Jr.**, Secy.-Supt., Escondido Mutual Water Co., Box 487, Escondido, Calif. (Jul. '57) *M*

**Fox, I. Ralph**, Vice-Pres., Broadway Maintenance Corp., 1271 McCarter Hgy., Newark, N.J. (Jul. '57) *RD*

**Frantz, Robert L.**, Chief Operator, Water Treatment Plant, North Palm Beach Utilities, Inc., Box 127, Lake Park, Fla. (Jul. '57) *P*

**Ginn, Dale E.**, Dist. Mgr., Pittsburgh-Des Moines Steel Co., 323 Railway Exchange Bldg., Denver 2, Colo. (Jul. '57)

**Gosselin, Alvin H.**, Supt., Pinellas County Water System, 309 Haven St., Clearwater, Fla. (Jul. '57) *M*

**Hamel, Theodore**, Supt., Dept. of Public Works, 36 Main St., Agawan, Mass. (Jul. '57) *MD*

**Harvey, Howard D.**, Sales Repr., Johns-Manville Sales Corp., Box 1872, Great Falls, Mont. (Jul. '57) *D*

**Haven, Robert C., Jr.**, Public Admin. Service, Bureau of Munic. Research, 1321 Arch St., Philadelphia, Pa. (Jul. '57)

**Hector, Milton T.**, Engr., Pacific Power & Light Co., Public Service Bldg., Portland 4, Ore. (Jul. '57) *MRPD*

**Hein, R. L.**; *see* Erie Mining Co.

**Henry, William**, Dist. Mgr., Rockwell Mfg. Co., Box 2126, Houston, Tex. (Jul. '57) *D*

**Hudgens, Ellsworth W.**, Sales Engr., Dowell Inc., 10 S. Brentwood, St. Louis 5, Mo. (Jul. '57) *MRPD*

**Ibbatron, Tom R.**; *see* Town of Winfield (Iowa)

**Jeroff, M. L.**, Munic. Engr., Municipality of W. Kildonan, 1760 Main St., West Kildonan, Winnipeg, Man. (Jul. '57)

**Johnson, Nick G.**, Asst. Director, Div. of Eng., State Dept. of Health, 1340 S. 3rd St., Louisville 8, Ky. (Jul. '57)

**Kear, Carl I.**; *see* Pottsville (Pa.) Water Co.

**Kugiya, Thomas Tadayuki**, Asst. Engr., State Water Survey Div., Box 232, Urbana, Ill. (Jul. '57) *MRP*

**Lee, Thomas B.**, Asst. City Engr., Dept. of Public Works, 300 City-County Bldg., Nashville 3, Tenn. (Jul. '57) *PD*

**Leopold, Luna B.**, Chief Hydr. Engr., U. S. Geological Survey, Washington 25, D.C. (Jul. '57)

**Lockwood, Bronson E.**, Supt., Fire Dist., Watertown, Conn. (Jul. '57) *MPD*

**MacKay, Edward A.**, Director of Public Works, Lombard, Ill. (Jul. '57) *M*

**Maurer, A. M.**, Branch Mgr., Peerless Pump Div., Food Machinery & Chem. Corp., Box 824, Albuquerque, N.M. (Jul. '57) *RD*

**McGeffan, James**, Supt., Public Works, City Hall, Rolling Meadows, Ill. (Jul. '57) *M*

**Meals, Joe O.**, Application Engr., Water & Waste Treatment Div., Bailey Meter Co., 7 N. Brentwood Blvd., St. Louis 5, Mo. (Jul. '57) *PD*

**Mentzer, Twitchell E.**, Office Mgr., E. St. Louis & Interurban Water Co., 513 Missouri Ave., East St. Louis, Ill. (Jul. '57) *MD*

**Merritt, Randolph Stewart**, Regional Sales Repr., Adams Pipe Repair Products, Box 9215, Richmond 27, Va. (Jul. '57) *D*

**Mitnick, Lawrence R.**, Supt., Lower Township Water Co., 520 Bayshore Rd., North Cape May, N.J. (Jul. '57) *M*

**Morgan, James J.**, Instructor in Civ. Eng., Univ. of Illinois, Urbana, Ill. (Jul. '57) *P*

**Mountain View, City of**, John C. Pursor, Public Works Supervisor, City Hall, Mountain View, Calif. (Munic. Sv. Sub. Jul. '57) *MRD*

**Mullins, Rubin Thomas**, Water Plant Operator, Station 8, Bldg. 510, Public Works Center, Asan Point, Guam (Jul. '57) *MRPD*

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**Nava, Roger E.;** *see* Univ. of Zulia Eng. Faculty

**Neal, William Henry,** Owner, Acme Drilling Co., 321 Jefferson Davis Ave., Montgomery 5, Ala. (Jul. '57) *R*

**Northcutt, John W.,** Asst. Vice-Pres., Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa. (Jul. '57) *M*

**O'Neill, C. William,** Governor, State House, Columbus, Ohio (Jul. '57) *P*

**Pearson, Roger F.,** Field Engr., Infilco, Inc., Tucson, Ariz. (Jul. '57) *P*

**Pederson, Donald E.,** Sales Engr., Rockwell Mfg. Co., Box 2126, Houston 1, Tex. (Jul. '57)

**Peters, Francis W.,** Hydrographic Control Engr., Dept. of Water & Power, 410 Ducommun St., Los Angeles 12, Calif. (Jul. '57) *RD*

**Pfeffer, Richard H.,** Chief Ranger, Fish & Game Dept., Munic. Bldg., Oklahoma City, Okla. (Jul. '57) *R*

**Ross, Robert J.,** City Engr., City Hall, Marinette, Wis. (Jul. '57) *MRPD*

**Pottsville Water Co.,** Carl I. Kear, Gen. Mgr., 221 S. Center St., Pottsville, Pa. (Corp. M. Jul. '57) *MRD*

**Puckorius, Paul R.,** Staff Engr., National Aluminate Corp., 6216 W. 66th Pl., Chicago 38, Ill. (Jul. '57) *MRP*

**Pursor, John C.;** *see* City of Mountain View (Calif.)

**Rathburn, Leroy Giles,** Civ. Engr., Bd. of Water Supply, Box 3410, Honolulu, Hawaii (Jul. '57) *D*

**Reckert, Robert D.,** Partner, DeWild & Grant, 208½—1st Ave., Rock Rapids, Iowa (Jul. '57) *RPD*

**Robitaille, Jean,** City Engr., City Hall, Church St., Ste-Foy, Que. (Jul. '57) *MD*

**Sapsford, Robert Oliver,** Sales Engr., Hersey Mfg. Co., South Boston 27, Mass. (Jul. '57) *MD*

**Schmidt, Andrew A., Jr.,** Water Comr., 9540 Irving Park, Schiller Park, Ill. (Jul. '57) *M*

**Snow, H. O., Jr.,** Chief Operator, Filter Plant, Tuscaloosa, Ala. (Jul. '57)

**Spears, J. Frank,** Supt., Water Dept., Hartwell, Ga. (Jul. '57) *M*

**Strickland, Harold R.,** Sales Engr., Rockwell Mfg. Co., Box 2126, Houston, Tex. (Jul. '57) *D*

**Strong, J. Ivor,** Pres., Strong, Lamb & Nelson, Ltd., 504—4th St., S.E., Calgary, Alta. (Jul. '57)

**Sullivan, John L.,** Sales Engr., Dresser Mfg. Div., 205 Fieldstone Dr., Glenshaw, Pa. (Jul. '57) *MD*

**Surber, Frederick K.,** Mayor, Tipton Water Co., Tipton, Ind. (Jul. '57)

**Tattersall, Gilbert,** Sales Engr., B-I-F Industries, Inc., 5430 Jillson St., Los Angeles 22, Calif. (Jul. '57) *PD*

**Welch, James J.,** City Engr., Little Falls, N.Y. (Jul. '57) *MD*

**Williamson, Richard H.,** Sr. Design Engr., Pacific Gas & Electric Co., 245 Market St., San Francisco 6, Calif. (Jul. '57) *MRD*

**Williman, Pauline E.,** Official Reporter, State Water Power & Control Com., 110 State St., Albany, N.Y. (Jul. '57) *RP*

**Winfield, Town of,** Tom R. Ibbatron, Water Supt., Winfield, Iowa (Munic. Sv. Sub. Jul. '57) *MPD*

**Wright, Frank H.,** Sr. Civ. Engr., Div. of Water, Columbus, Ohio (Jul. '57) *RD*

**Zulia, Univ. of, Eng. Faculty,** Roger E. Nava, Director, Maracaibo, Venezuela (Corp. M. Jul. '57) *MRPD*

# Index of Advertisers' Products

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Alco Products, Inc.
Allis-Chalmers Mfg. Co.
United States Pipe & Foundry Co.

**Contractors, Water Supply:**
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**Controllers, Liquid Level, Rate of Flow:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Fischer & Porter Co.
Foxboro Co.
General Filter Co.
Infilco Inc.
Simplex Valve & Meter Co.
Sparling Meter Co.

**Copper Sheets:**
American Brass Co.

**Copper Sulfate:**
General Chemical Div.
Phelps Dodge Refining Corp.
Tennessee Corp.

**Corrosion Control:**
Alco Products, Inc.
Calgon Co.
Philadelphia Quartz Co.

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DeLaval Steam Turbine Co.
Dresser Mfg. Div.

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Dorr-Oliver Inc.
Southern Pipe & Casing Co.

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Ross Valve Mfg. Co.

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(See Professional Services)

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Allis-Chalmers Mfg. Co.
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Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)

**Ferric Sulfate:**
Tennessee Corp.

**Filter Materials:**
Anthracite Equipment Corp.
Carborundum Co.
Dicalite Div.
General Filter Co.
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Johns-Manville Corp.
Northern Gravel Co.
Permutit Co.
Carl Schleicher & Schuell Co.
Stuart Corp.

**Filters, incl. Feedwater:**
Cochrane Corp.
Dorr-Oliver Inc.
Etablissements Degremont
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

**Filters, Membrane (MF):**
AG Chemical Co.
Millipore Filter Corp.
Carl Schleicher & Schuell Co.

**Filtration Plant Equipment:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chain Belt Co.
Cochrane Corp.
Etablissements Degremont
Filtration Equipment Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Permutit Co.
Roberts Filter Mfg. Co.
Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

**Fittings, Copper Pipe:**
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

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Alco Products, Inc.
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Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
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M & H Valve & Fittings Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

**Flocculating Equipment:**
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Cochrane Corp.
Dorr-Oliver Inc.
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Infilco Inc.
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Permutit Co.
Stuart Corp.

**Fluoride Chemicals:**
American Agricultural Chemical Co.
Davison Chemical Co.

**Fluoride Feeders:**
Fischer & Porter Co.
Milton Roy Co.
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Co., Inc.

**Furnaces:**
Jos. G. Pollard Co., Inc.

**Gages, Liquid Level:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Infilco Inc.
Simplex Valve & Meter Co.
Sparling Meter Co.
Wallace & Tiernan Inc.

**Gages, Loss of Head, Pressure of Vacuum, Rate of Flow, Sand Expansion:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Foxboro Co.
Infilco Inc.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

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Bethlehem Steel Co.
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Armco Drainage & Metal Products, Inc.
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R. D. Wood Co.

**Gears, Speed Reducing:**
DeLaval Steam Turbine Co.
Worthington Corp.

**Glass Standards—Colorimetric Analysis Equipment:**
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Wallace & Tiernan Inc.

**Goosenecks (with or without Corporation Stops):**
James B. Clow & Sons
Hays Mfg. Co.
Mueller Co.

**Hydrants:**
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
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Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.

**Hydrogen Ion Equipment:**
Wallace & Tiernan Inc.

**Hypochlorite; see Calcium Hypochlorite; Sodium Hypochlorite**

**Ion Exchange Materials:**
Allis-Chalmers Mfg. Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.

**Iron, Pig:**
Woodward Iron Co.

**Iron Removal Plants:**
American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

**Jointing Materials:**
Hydraulic Development Corp.
Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

**Joints, Mechanical, Pipe:**
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

**Leak Detectors:**
Jos. G. Pollard Co., Inc.

**Lime Slakers and Feeders:**
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Permutit Co.
Wallace & Tiernan Inc.

**Magnetic Dipping Needles:**
W. S. Darley & Co.

**Meter Boxes:**
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

**Meter Couplings and Yokes:**
Badger Meter Mfg. Co.
Dresser Mfg. Div.

Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Worthington-Gamon Meter Co.

**Meter Reading and Record Books:**
Badger Meter Mfg. Co.

**Meter Testers:**
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

**Meters, Domestic:**
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

**Meters, Filtration Plant, Pumping Station, Transmission Line:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
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Infilco Inc.
Simplex Valve & Meter Co.
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**Meters, Industrial, Commercial:**
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Buffalo Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Fischer & Porter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

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James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
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**Pipe, Cement Lined:**
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.

**Pipe, Concrete:**
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
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**Pipe, Copper:**
American Brass Co.

**Pipe, Steel:**
Alco Products, Inc.
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**Pipe Cleaning Services:**
Ace Pipe Cleaning, Inc.
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**Pipe Cleaning Tools and Equipment:**
Flexible Inc.

**Pipe Coatings and Linings:**
American Cast Iron Pipe Co.
Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.

**Pipe Cutters:**
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
Reed Mfg. Co.
A. P. Smith Mfg. Co.
Spring Load Mfg. Corp.

**Pipe Jointing Materials; see Jointing Materials**

**Pipe Locators:**
W. S. Darley & Co.
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Reed Mfg. Co.
Spring Load Mfg. Corp.

**Plugs, Removable:**
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A. P. Smith Mfg. Co.

**Potassium Permanganate:**
Carus Chemical Co.

**Pressure Regulators:**
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Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

**Pumps, Boiler Feed:**
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.
Worthington Corp.

**Pumps, Centrifugal:**
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.
Worthington Corp.

**Pumps, Chemical Feed:**
Infilco Inc.
Milton Roy Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

**Pumps, Deep Well:**
American Well Works
Layne & Bowler, Inc.
Layne & Bowler Pump Co.
Worthington Corp.

**Pumps, Diaphragm:**
Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

**Pumps, Hydrant:**
W. S. Darley & Co.
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**Pumps, Hydraulic Booster:**
Ross Valve Mfg. Co.

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Allis-Chalmers Mfg. Co.
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**Pumps, Sump:**
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**Pumps, Turbine:**
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Layne & Bowler Pump Co.

**Recorders, Gas Density, $CO_2$, $NH_3$, $SO_2$, etc.:**
Permutit Co.
Wallace & Tiernan Inc.

**Recording Instruments:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
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Fischer & Porter Co.
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**Reservoirs, Steel:**
Bethlehem Steel Co.
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**Sand Expansion Gages; see Gages**

**Sleeves: see Clamps**

**Sleeves and Valves, Tapping:**
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**Sludge Blanket Equipment:**
General Filter Co.
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Permutit Co.

**Sodium Aluminate:**
Monolith Portland Midwest Co.

**Sodium Chloride:**
Frontier Chemical Co.
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**Sodium Fluoride**
American Agricultural Chemical Co.

**Sodium Hexametaphosphate:**
Calgon Co.

**Sodium Hypochlorite:**
John Wiley Jones Co.
Wallace & Tiernan Inc.

**Sodium Silicate:**
Philadelphia Quartz Co.

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American Agricultural Chemical Co.

**Softeners:**
Cochrane Corp.
Dorr-Oliver Inc.
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Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

**Softening Chemicals and Compounds:**
Calgon Co.
Cochrane Corp .
General Filter Co.
Infilco Inc.
International Salt Co., Inc.
Permutit Co.
Tennessee Corp.

**Standpipes, Steel:**
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Tank & Mfg. Co.

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

**Steel Plate Construction:**
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

**Stops, Curb and Corporation:**
Hays Mfg. Co.
Mueller Co.

**Storage Tanks: see Tanks**

**Strainers, Suction:**
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

**Surface Wash Equipment:**
Cochrane Corp.
Permutit Co.

**Swimming Pool Sterilization:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

**Tanks, Steel:**
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

**Tapping-Drilling Machines:**
Hays Mfg. Co.
Mueller Co.
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**Tapping Machines, Corp.:**
Hays Mfg. Co.
Mueller Co.

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Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

**Tenoning Tools:**
Spring Load Mfg. Corp.

**Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):**
Wallace & Tiernan Inc.

**Turbines, Steam:**
Allis-Chalmers Mfg. Co.
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Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

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James B. Clow & Sons
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M & H Valve & Fittings Co.
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Rensselaer Valve Co.
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**Valve-Inserting Machines:**
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A. P. Smith Mfg. Co.

**Valves, Altitude:**
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Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

**Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

**Valves, Detector Check:**
Hersey Mfg. Co.

**Valves, Electrically Operated:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

**Valves, Float:**
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

**Valves, Gate:**
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

**Valves, Hydraulically Operated:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

**Valves, Large Diameter:**
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Muller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

**Valves, Regulating:**
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

**Valves, Swing Check:**
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

**Venturi Tubes:**
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Infilco Inc.
Simplex Valve & Meter Co.

**Waterproofing:**
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

**Water Softening Plants; see Softeners**

**Water Supply Contractors:**
Layne & Bowler, Inc.

**Water Testing Apparatus:**
Wallace & Tiernan Inc.

**Water Treatment Plants:**
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Etablissements Degremont
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

**Well Drilling Contractors:**
Layne & Bowler, Inc.

**Wrenches, Ratchet:**
Dresser Mfg. Div.

**Zeolite: see Ion Exchange Materials**